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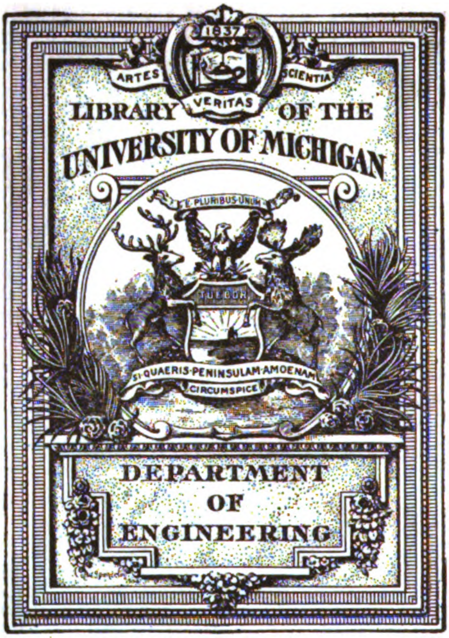

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ANNUAL REPORTS

OF THE

WAR DEPARTMENT

FOR THE

FISCAL YEAR ENDED JUNE 30, 1903.

VOLUME XIII.

SUPPLEMENT TO THE REPORT OF THE CHIEF OF ENGINEERS.

REPORT OF THE MISSISSIPPI RIVER COMMISSION.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1903.

ARRANGEMENT OF THE ANNUAL REPORTS OF THE WAR DEPARTMENT FOR THE YEAR ENDED JUNE 30, 1903.

Volume I.—Secretary of War:
- Chief of Staff.
- Adjutant-General.
- Inspector-General.
- Judge-Advocate-General.

Volume II.—Armament, Transportation and Supply:
- Quartermaster-General.
- Commissary-General.
- Surgeon-General.
- Paymaster-General.
- Chief of Engineers, Military Affairs.
- Chief of Ordnance.
- Chief Signal Officer.
- Chief of Artillery.
- Board of Ordnance and Fortification.

Volume III.—Department and Division Commanders:
- Department of California.
- Department of the Colorado.
- Department of the Columbia.
- Department of Dakota.
- Department of the East.
- Department of the Lakes.
- Department of the Missouri.
- Department of Texas.
- Division of the Philippines—
    1. Department of Luzon.
    2. Department of the Visayas.
    3. Department of Mindanao.

Volume IV.—Military Schools and Colleges; Record and Pension Office; Military Parks, and Soldiers' Homes:
- Military Academy—
    1. Board of Visitors.
    2. Superintendent.
- Army War College.
- General Service and Staff College.
- School of Application for Cavalry and Field Artillery.
- Artillery School.
- School of Submarine Defense.
- Chief of Record and Pension Office.
- Commissioners of National Military Parks—
    1. Chickamauga and Chattanooga.
    2. Gettysburg.
    3. Shiloh.
    4. Vicksburg.
- Soldiers' Home, District of Columbia—
    1. Board of Commissioners.
    2. Inspection of.
- Inspection of National Home for Disabled Volunteer Soldiers.

Volumes V-VIII.—Reports of the Philippine Commission, the Chief of Bureau of Insular Affairs, and Acts of the Philippine Commission.

Volumes IX-XIII.—Chief of Engineers, River and Harbor Improvements.

134865

[To be inserted at page 3, Annual Report of Chief of Engineers, 1903, Supplement.]

ERRATA

IN THE REPORT OF THE MISSISSIPPI RIVER COMMISSION FOR THE FISCAL YEAR ENDING JUNE 30, 1903, AS PRINTED IN THE ANNUAL REPORT OF THE CHIEF OF ENGINEERS, 1903, SUPPLEMENT.

NOTE.—The following list includes only errors of quantity or sense.

Page 31.—18th line from bottom, for April, 1902 read April, 1903.

" 111.—Table discharge observations, Grafton, Ill., column marked "Standard gauge",
for 28.2 read 28.5.
for 28.4 read 28.7.

" 145.—27th line, for 6¼ per cent. read 2.9 per cent.
1st line in table, last three columns,
for 71.0 | 26.08 | 50.27 read 67.4 | 22.59 | 46.86.

" 146.—Table, 1st line, last column, for 66.6 read 65.7.

Pages 156-157.—The following quantities will be substituted for those printed in the corresponding columns of table of dredge tests, for dredge *Iota*, on pages 156 and 157:

	Heads, feet of water.				Work done Ft. lbs. per sec.	Efficiency of pumps and engine; per cent.
	Suction.	Delivery.	Velocity.	Total.		
Iota......	9.74	26.55	.60	36.89	230,864.63	62.0
	10.71	31.75	.70	43.16	231,721.32	62.6
	10.68	31.85	.72	43.25	236,388.08	63.7
	10.77	31.80	.71	43.28	234,795.84	63.8
	10.79	33.80	.77	45.36	309,711.52	64.9
	11.22	33.70	.77	45.69	312,065.44	65.4

Page 157.—5th line, 2nd, 3rd and 4th columns:
for 178,762.58 | 71 | 76.7 read 163,144.65 | 64.8 | 70.0.

" 158.—1st table, 4th column, should be decimal point in place of comma, for 8,337 read 8.337 etc.

" 178.—12th line, for 20, 21 read 20*, 21*, and insert foot-note * Hushpuckana levee.

" 179.—17th line from bottom, for 810 miles read 810 square miles.

" 211.—1st line, for sike read dike.

" 216.—21st line from bottom, for mile post [illegible] read mile post [illegible].

" 239.—12th line of report of Mr. G. C. Thomas, for (542 L) read (542 R).

" 260.—19th line from bottom, for stations 0 to 665 read stations 0 to 655.

" 266.—3rd line from bottom of first table, 2nd column, "Miles below Cairo", for 383 read 583.

" 281.—3rd line from bottom of 1st table, 3rd column, "Miles below Cairo", for 238 read 738.

" 282.—9th line from bottom of 1st table, 2nd column, for section 4 read section 3.
3rd line from bottom of 2nd table, 2nd column, for section 4 read section 3.
7th line from bottom of 2nd table, 8th column, for 3,520 read 3,320.

" 285.—6th line from bottom of 1st table, 6th column, for 11,300 read 1,300.

" 306.—9th line from bottom, for Gomstook read Comstock.

" 317.—Table, 3rd column from end, opposite Hope insert 1882.
2nd line from bottom of 7th column, take out ditto mark.
Last column, opposite Solitude, insert 1896 three times.
Last column, opposite Hope, insert 1894.

ANNUAL REPORT OF THE MISSISSIPPI RIVER COMMISSION FOR FISCAL YEAR ENDING JUNE 30, 1903.

OFFICE MISSISSIPPI RIVER COMMISSION,
St. Louis, Mo., July 1, 1903.

SIR: The Mississippi River Commission has the honor to submit this its annual report for the fiscal year ending June 30, 1903.[a]

APPROPRIATIONS AND ALLOTMENTS.

The river and harbor bill approved June 13, 1902, appropriated $2,200,000, from which the following allotments were made:

Mississippi River Commission	$10,500	
Surveys, gauges, and observations	69,000	
Dredges and dredging	295,000	
		$374,500

FIRST AND SECOND DISTRICTS.

Repair of revetment works, Plum Point reach	105,000	
Low-water channel dikes	20,000	
Care, repair, and renewals of plant	70,000	
Levees	305,000	
Surveys	5,000	
Harbor at Caruthersville, Mo. (bank protection)	20,000	
Harbor of Memphis, Tenn. (dredging Wolf River)	10,000	
Harbor of Helena, Ark. (repairs to bank protection)	5,000	
		540,000

THIRD DISTRICT.

Repairs and extension of revetment work	135,000	
Care, repair, and renewal of plant	65,000	
Levees	403,500	
Surveys	5,000	
Harbor of Greenville, Miss. (bank protection)	25,000	
		633,500

FOURTH DISTRICT.

Repairs and extension of revetment at Bondurant and Kempe for the protection of levees	70,000	
Care, repair, and renewal of plant	111,000	
Levees	291,500	
Surveys	5,000	
Harbor of Natchez and Vidalia (bank protection)	60,000	
Rectification of Red and Atchafalaya rivers	15,000	
Harbor of New Orleans (bank protection)	95,000	
		647,500
In hands of president		4,500
		2,200,000

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[a] For list of appendixes, etc., see page 40.

In addition to the above items there were specific appropriations in the river and harbor act of June 13, 1902, as follows:

Repair and extension of Walnut Bend levee	$90,000
Surveys, examinations, and investigations for 14-foot waterway along the Mississippi River between the mouth of the Illinois River and St. Louis	25,000

Details of the expenditures of these allotments are appended hereto.

During the past fiscal year the following allotments and transfers of allotments were made:

ALLOTMENTS.

From reserve in hands of President to Mississippi River Commission (balance from sundry civil act June 6, 1900), approved July 5, 1902	$36,500
From reserve in hands of President to Lake Borgne levee district (from appropriation June 13, 1902)	2,000

TRANSFERS OF ALLOTMENTS.

From Plum Point Reach to plant first and second districts, approved March 23, 1903	35,000
From dikes to plant first and second districts, approved March 23, 1903	4,000

The sundry civil act approved March 3, 1903, appropriated $2,000,000, from which the following allotments were made:

Mississippi River Commission	$27,000	
Surveys, gauges, and observations	65,000	
Dredges and dredging	286,000	
		$378,000

FIRST AND SECOND DISTRICTS.

Repair of revetment works:		
Plum Point Reach	69,000	
Hopefield Bend	99,000	
Care, repair, and renewals of plant	60,000	
Levees	325,000	
Surveys	5,000	
Harbor of Helena, Ark	5,000	
Harbor of Memphis (including Wolf River)	8,000	
		571,000

THIRD DISTRICT.

Repairs and extension of revetment work	135,000	
Care, repair, and renewal of plant	77,000	
Levees	403,500	
Surveys	5,000	
Harbor of Greenville, Miss	25,000	
		645,500

FOURTH DISTRICT.

Repairs and extension of revetment work at Bondurant and Kempe for protection of levees	69,000	
Care, repair, and renewal of plant	47,000	
Levees	271,500	
Surveys	6,000	
Harbors of Natchez and Vidalia, Mississippi and Louisiana	12,000	
		405,500
		2,000,000

MISSISSIPPI RIVER COMMISSION.

The duties of the Commission, as defined by the act of June 28, 1879, are in the main as follows:

> To direct and complete such surveys of said river, between the Head of the Passes near its mouth and its headwaters, and to make such additional surveys, examinations, and investigations, topographical, hydrographical, and hydrometrical, of said river and its tributaries, as may be deemed necessary by said Commission to carry out the objects of this act. * * * To take into consideration and mature such plan or plans and estimates as will correct, permanently locate and deepen the channel, and protect the banks of the Mississippi River; improve and give ease and safety to the navigation thereof; prevent destructive floods; promote and facilitate commerce, trade, and the postal service. * * *

Under the authority of this act, and subsequent appropriations, these surveys have been carried on, and the systematic improvement of the navigation of two reaches of the river was begun in 1881. The construction of levees as a part of the improvement of the river also formed an important feature of the work.

The general repair and construction of levees was first authorized without qualifying restrictions by the act of September 19, 1890, and since that date this work has formed one of the most important items in the operations of the Commission, about one-half of the appropriations made by Congress being devoted to that purpose.

The work of systematic improvement of the channel by means of revetment and kindred construction was suspended by act of August 5, 1886; and as two years elapsed before another appropriation became available a large amount of the uncompleted work was necessarily lost.

The uncertainty of appropriations; and the inadequacy in the amounts allotted by Congress to this work, made it apparent that the systematic improvement of the navigation of the river under such conditions could not be hoped for within any reasonable period of time. The demands of commerce were such that temporary relief of some character was imperative. The system of hydraulic dredging was therefore adopted in 1896, and under the requirements of recent acts of Congress there is now maintained by this means a channel 9 feet in depth and 250 feet in width at all stages of the river from Cairo southward.

The construction and operation of dredges and the repair and building of levees have required so large a portion of the appropriations that the work of revetment of banks has been confined to specific work along harbor fronts and threatened levees and for the prevention of cut-offs, and the work for the rectification of the channel has been confined to the repair and maintenance of works that were begun in the two reaches, where such procedure was deemed advisable.

It is apparent, therefore, that systematic work, which has for its object to permanently locate and deepen the channel, has not been practicable under existing conditions. In the limited extension and repair of bank protection and contraction work the Commission has, however, kept in mind that the permanent improvement of the river is contemplated by the organic act, and experiments are continually being made looking to the best use of available material and the development of appliances and methods which may be economically and effectively employed when Congress shall provide for such systematic permanent improvement.

During the present year the Commission has held three sessions. Two of these were held on board the steamer *Mississippi* en route from

St. Louis down the river, for the purpose of inspecting the river and the works of improvement. The sessions were held on the following dates: Eighty-seventh session, on board U. S. steamer *Mississippi*, St. Louis up to mouth of Illinois River, thence to New Orleans, November 8–16, 1902; eighty-eighth session, St. Louis, Mo., to Passes, La., March 23–31, 1903; eighty-ninth session, June 24–26, 1903, St. Louis, Mo., for the consideration of allotments and future operations under the appropriations of March 3, 1903. At all of these meetings hearings were given to the representatives of the navigation and commercial interests of the river.

During the year the membership of the Commission was changed by the relief of the president, Col. Amos Stickney, Corps of Engineers, U. S. Army, and the appointment of Col. Oswald H. Ernst, Corps of Engineers, U. S. Army, as president, on February 25, 1903.

The following changes have occurred in the personnel of the officers in charge of works under the Commission:

Capt. E. W. Van C. Lucas, Corps of Engineers, U. S. Army, relieved Capt. E. Eveleth Winslow, Corps of Engineers, U. S. Army, of his duties in charge of the First and Second districts on October 31, 1902.

Capt. Chas. S. Bromwell, Corps of Engineers, U. S. Army, relieved Maj. Geo. McC. Derby, Corps of Engineers, of his duties in charge of the Fourth district on September 30, 1902.

Capt. Wm. B. Ladue, Corps of Engineers, U. S. Army, relieved Capt. Geo. P. Howell, Corps of Engineers, U. S. Army, of his duties as secretary of the Commission on April 22, 1903. Headquarters, Fullerton Building, St. Louis, Mo.

The duties of the secretary comprise the record and publication of the Commission's transactions, the conduct of the survey of the Mississippi River, including gauging and discharge measurements of the Mississippi River and tributaries, the operation of the dredges, and the care and repair of same.

SURVEYS, GAUGES, AND OBSERVATIONS.

The survey was extended north of Aitkin, Minn., a refined tape-line measurement being made from Aitkin up to end of the work near Grand Rapids, Minn., which was brought down the river from Itasca Lake during the preceding season. A line of levels was also run over the same route, thus completing the azimuth line and precise levels along the banks of the river to the head of Itasca Lake, and closing circuits of 275 miles of geodetic work and 220 miles of precise levels. The field notes of these measurements have been reduced and the results tabulated.

Topography and hydrography were taken up at Aitkin, Minn., in February, 1903, and the work extended northward to Pokegama dam, a distance of 82 miles, where operations were suspended owing to the flooded condition of the swamps adjacent to the river. The work was done mainly during the winter when the ground was frozen and buried deep in snow, but the results seem to indicate that the winter is by far the best season to carry on the topographical survey in that region where swamps abound.

A low-water survey between Cairo and the mouth of the Arkansas River was begun at Cairo on the 4th of October, 1902. The object of this survey was to determine the present shore line and to furnish data which could be used in studying the changes that have developed since the construction of the levees along the St. Francis front. This survey was completed for a distance of 203 miles to Corona Landing, at which point the work was suspended on account of high stage of river. This work will be extended to the Arkansas River at the next suitable low-water season. The results of this survey will be compared with those of the first general survey made in 1880 to 1882 in a similar way to the comparisons made of that portion of the river between the Arkansas River and Donaldsonville, in order to determine the general changes that have occurred in the bed and banks during the interval of twenty years.

SURVEYS AND EXAMINATIONS FOR NAVIGABLE WATERWAY, 14 FEET IN DEPTH, BETWEEN MOUTH OF ILLINOIS RIVER AND ST. LOUIS, MO.

The river and harbor act of June 13, 1902, provided for such surveys, examinations, and investigations as may be necessary to determine the feasibility of and to prepare and report plans and estimates of cost of a navigable waterway, 14 feet in depth, from Lockport, Ill., to St. Louis, Mo. The portion of this reach under the Mississippi River Commission comprises the Mississippi River from the mouth of the Illinois River to St. Louis. A survey of this reach was begun August 28, 1902, at the mouth of the Illinois River, and completed on September 30, 1902, to the head of Arsenal Island, the distance covered by the survey being 43.6 miles. The work consisted of location of the bank lines, the topography of the adjacent banks and islands, and cross sections of the river at intervals of 500 feet. Lines of levels were also run along the river banks to determine the elevation and slope of the water surface. The survey was based on the general survey made by the Commission in 1889–1891. The bench marks and triangulation points of that survey were used throughout.

The stage at which the work was done ranged from 14 feet to 7 feet and was higher than desirable for the best results, but by supplementing it with further data at a lower stage it will answer all purposes. There is still required an extension of the topographical work at some points, a series of borings and such other work as may develop when the study of the proposed improvement is taken up. The survey has been platted on a scale of 1:4,800, the configuration of the ground being shown by 5-foot contours.

MAPPING AND REDUCTION OF FIELD NOTES.

The reduction of field notes and the platting and drawing of maps has been continued in the office. Six detail charts, Nos. 213 to 218, inclusive, extending from Minneapolis, Minn., northward, were completed. A map of Itasca Basin on the scale of 1:15,000 was drawn and printed in colors. Three detail charts, Nos. 187, 188, and 189, scale 1:20,000, were published, completing the series from the Head of the Passes northward to and including the cities of St. Paul and Minneapolis. A title sheet and index map covering the river between Cairo and Minneapolis have also been prepared to issue with this series of detail charts. A map of the St. Francis Basin in two sheets, on a scale of 1 inch to 1 mile, has been completed with the exception of the shore line, which will be entered thereon when the low-water survey is completed.

GAUGES.

The permanent gauges of the Commission have been maintained during the year. These now include a total of 38 gauges, comprising

17 established by the Commission and 21 transferred to the care of the Commission by the United States Engineer Office in Vicksburg. Careful record of the stages at each of these gauges is kept, and these readings are compiled and published in an annual stage pamphlet, showing the readings morning and evening for each day in the year. The gauges are inspected at high and low water, and the zeroes are carefully maintained.

Self-registering tide gauges have been maintained at Biloxi, Miss., and East Bay, Louisiana.

For the determination of high-water slope 185 gauges have been established between Cairo and Fort Jackson at intervals of about 5 miles. Readings are made on each of these at the crest of the flood, and the profile of the high water is completed from these results.

DISCHARGE MEASUREMENTS.

Discharge measurements of the Mississippi River were made at or near the maximum stage during the flood of 1903 at Columbus, Ky.; Helena, Ark., Arkansas City, Ark., Warrenton, Miss., Red River Landing, La., and Carrollton, La. The discharge at high-water stages was also measured during high water on the Red River at Alexandria, La.; on the Atchafalaya River at Simmesport; on the Yazoo near Haines Bluff; on the Black River at Jonesville, La. Approximate measurements were made of the discharges of Bayou Lafourche and Hymelia crevasse during the recent flood.

The great floods in the Missouri and Mississippi, which reached the junction of these streams about the same date, culminated in a stage of 38 feet on June 10 at St. Louis. Discharge measurements of the combined flood were made at Thebes, Ill., 45 miles above Cairo. The volume at the crest of the flood in the upper Mississippi was also measured at Grafton, Ill., just below the mouth of the Illinois River.

Further detailed accounts of the above work will be found in the report of the secretary and the appendices thereto.

DREDGES AND DREDGING.

The dredge *Alpha* having been dismantled there remained eight dredges available for service. All of these were put in commission and were assigned to different reaches of the river. The *Beta*, however, was employed at South Pass until near the close of the season. No work was done by the *Zeta* and but one day's work by the *Epsilon*. The other five dredges were employed at intervals throughout the season.

The dredging operations covered the low-water intervals during the period from the latter part of August to the latter part of November. The season was unusually favorable as far as the stage of the river was concerned, and as a consequence but little time was actually employed in dredging.

The stage conditions during the dredging season were as follows: On August 19 the falling stage reached 16 feet on the Cairo gauge and remained within a foot of that stage for four days; then a rise set in, culminating at 19 feet September 1. After that date there was a steady fall which reached a 7-foot stage September 26. A second rise came, which reached 20 feet on October 11, and was followed by a drop to 16 feet by October 21, remaining near that stage with but slight oscillations until October 26, when a further decline set in, reaching 9¾ feet November 8. The stage continued near this point until November 20, when a steady rise set in which obviated the necessity for further work. The drawings accompanying the secretary's report show very clearly the development of navigable channels by means of dredging, and are worthy of more than ordinary consideration.

Dredging during the season was confined to the river between Darnells Bar (80) and Ashley Point (271). In this reach channels were opened through 11 different bars, and some dredging was done to remove the bar in front of Memphis wharf. A depth of 9 feet or more was maintained throughout the entire season on all crossings from Cairo to the lower limits covered by the dredging operations.

The maintenance of a navigable channel ample in width and depth throughout several successive low-water seasons emphasizes the conclusions announced in previous reports—that it is entirely practicable to maintain at all stages, by means of suitable equipment of dredges, a navigable channel at least 9 feet in depth and 250 feet in width, as required by act of Congress.

For detailed accounts of dredging operations, see report of F. B. Maltby, assistant engineer, appended hereto.

DREDGE TESTS.

In the development of a dredging plant that will fully meet the requirements in the speedy removal of the rapidly shifting sandbars that obstruct the low-water navigation of the Mississippi River, the Commission entered practically a new field, with no precedents of any considerable value to guide it. The first efforts were naturally directed toward the construction of a dredge of great capacity that would be sufficiently powerful to readily cut a channel through any bar which threatened to obstruct navigation, and to open this channel even before the bar became an actual obstruction. It was therefore desirable to try several different types of pumps and engines, as well as other parts that go to make up a complete dredge. An effort was made, as one dredge after another was built, to eliminate the defects that were developed by actual use in the field, and very material improvements have been made both in capacity and facility of operation. The eight dredges now composing the dredging plant contain several different types of pumps, engines, and other features.

Having determined the general type of dredge which would effectively do the work required, the next step would naturally be to ascertain which type would do the required work in the most efficient manner with the least cost. In order to decide this matter, an elaborate series of tests of the several dredges was undertaken, under the direction of the committee on dredges and dredging, to ascertain as far as practicable what was actually being accomplished by each dredge under normal working conditions. These tests included the determination of the efficiency of boilers, engines, sand and jet pumps, giving due consideration to the results required in economical dredging work. Measurements of flow in suction and discharge pipes, and also observations of the movements of the material in the sand pump itself, were made. Consideration was given to the most efficient form of suction head, to the loss of head due to different lengths of discharge pipe and to bends therein, to the determination of the most efficient speed of sand pump and the number of blades required to give the best results, and the investigations were extended to various other elements of a working dredge.

A considerable portion of these tests covers a field which has heretofore received but little or no consideration from hydraulic investigators, and the results obtained will doubtless prove to be valuable contributions to the literature of hydraulic dredging. All of the tests contemplated have not as yet been completed, but will be continued as time is available during the coming season. The valuable data already secured will be utilized in designing the new dredge whose construction has been provided for.

The tests have been carried on during the past season, under the supervision of the secretary, by Asst. Engineer F. B. Maltby, assisted by Prof. W. B. Gregory, whose reports are appended hereto.

CHANNEL WORKS, BANK PROTECTION, AND HARBOR IMPROVEMENTS IN THE SEVERAL DISTRICTS.

Bank protection or revetment work has been confined to harbors, caving banks threatening the destruction of important levees, and to the repairs of works relating to the general regulation of the river. In carrying on this work several types of revetment are being tried with a view to the ultimate development of some practicable method of securely fixing the banks, the cost of which will permit of its general use in their systematic revetment, should Congress decide to enter upon such project.

In this work the element of time is of the greatest importance, and no just estimate of the efficiency of any particular revetment can be made until it has passed through many phases of high and low water, with all the intervening changes. To be effective it must stand the strain under all conditions, and the test of its efficiency necessarily covers a period of several years. It is therefore deemed important to continue experiments along lines which promise the greatest success.

Decided improvements have already been made since the work began. While the earlier form of revetment was found to be defective in many ways and soon yielded to the strain which came upon it, the type now in general use is far more substantial and serves to hold the most difficult banks. In other words, we have reached a stage in the development of bank-protection work where we can confidently undertake to prevent further bank recession at places where the interests involved will justify the expense. The experiments that are being made look chiefly to increase in durability and strength and to reduction in cost. They involve the substitution of brick or artificial stone for ballast and upper bank paving on the lower reaches where stone is expensive; the use of concrete for covering the upper bank in lieu of stone; of lumber for mattresses in lieu of willows; of wooden frames and pins in mattress construction in lieu of wires and cables. The results obtained with these different types of revetment will be faithfully noted, and such features as are found to be valuable will be incorporated in future work.

In connection with low-water channel works the abattis dikes have proven effective wherever used for the purpose of inducing deposits in side chutes or extending shore sand bars for the purpose of contracting low-water channels.

Works above Cairo.—Headquarters custom-house, St. Louis, Mo. Maj. Thos. L. Casey, Corps of Engineers, U. S. Army, in charge.

After the high water of July, 1902, a break of about 175 feet long was found in the revetment which protected the bank a short distance above Cairo. This break threatened the destruction of the levee that protects the city from overflow. The defect was repaired by means of a short spur dike and a renewal of the broken revetment. This exhausted the balance of the appropriation of 1884, amounting to $2,571.70. Further work in this locality, should any be needed, will be carried on with funds from the appropriation for improving Mississippi River between the Ohio and Missouri rivers.

First district, from Cairo, Ill., to the foot of Island 40 (220 miles).—Headquarters 280 Second street, Memphis, Tenn. District officers: Capt. E. Eveleth Winslow to October 31, 1902, and from October 31, 1902, Capt. E. W. Van C. Lucas.

Construction works for channel improvement, protection of caving banks and harbor work in this district, are located at Columbus, Ky., Hickman, Ky., New Madrid, Mo., and Caruthersville, Mo., and Plum Point Reach, together with certain isolated works of low-water channel dikes at different points throughout the district.

Columbus, Ky., 21 miles below Cairo, left bank.—The work at this point consisted in the construction of submerged spur dikes covering the harbor front for a distance of about 2,200 feet. This work was done in 1889 to 1890. No repairs have been made since that time, and the bank line has been held in satisfactory manner. The last inspection showed some slight deterioration in the work extending above the low-water line, and it is altogether probable that slight repairs will be required during the coming season. Considerable caving occurred along the bluffs a short distance above the work, but it is hardly probable that this will need revetment protection, no immediate danger being apprehended.

Hickman, Ky., 36 miles below Cairo, left bank.—The work at this point consists of 1,650 feet of continuous revetment, which was put in to prevent caving along the lower portion of the town. This work was constructed in 1889, 1892, and 1894. Slight repairs were made in the year 1900 on account of injury done to the revetment by local drainage. At the present time the work is in good condition and no further work is contemplated in the near future.

New Madrid, Mo., 71 miles below Cairo, right bank.—This work consists of bank revetment extending along the river front of the town. It consists of continuous revetment of the fascine type of mat 250 feet wide below low water, and riprap paving on the graded bank above low water. Some 900 feet of this work was constructed in 1893, and during the following year was extended 700 feet. In 1896 a further extension of 500 feet was made; in 1898 the work was extended 1,218 feet downstream and 355 feet upstream. In 1900 a further downstream extension was made of 1,000 feet, making a total length of 4,673 feet. The work in general is in good condition excepting a few places near the low-water line which will require minor repairs by means of stone paving as soon as the stage of river will permit.

Caruthersville, Mo., 110 miles below Cairo, right bank.—This work consists of spur dikes and continuous revetment for the purpose of protecting the caving bank in front of the town. The revetment covers a total length of 2,342 feet. The rapid caving a short distance below this revetment may require further extension downstream in the near future. Slight repairs will also be required to the revetment already in place.

Plum Point Reach, 147 to 186 miles below Cairo.—The work in this reach comprises about 67,400 linear feet of revetment for the protection of caving banks, the closure of the chutes behind Elmot Bar and Island 30 with a brush and stone dam, the closure of Osceola and Bullerton chutes with pile dikes, and a levee along the left bank to confine the flood waters more closely to the river bed. The object of all these works is to increase the navigable depth at low water of a reach of river that had been noted for years for its obstructing sand bars, which were a source of great annoyance and loss to navigation interests. The result of this work is that the banks have remained practically fixed within the prescribed limits, and the navigable depth at low water has been increased to such an extent that little or no difficulty has been experienced in navigating this reach since the works approached completion.

At no time since the works were well under way has the navigable depth reached so low a point as it did nearly every low-water season prior to the construction of the rectification works. Dredging was done in this reach during two different low-water seasons in order to maintain the required depth of 9 feet. Before the improvement began depths of 4½ feet at low water were not uncommon. During the past year work in this reach has been confined to general repairs and to extension of revetment in some cases where caving has threatened to damage the same. The later work of the Daniels Point revetment is still in serviceable condition. In order to maintain the integrity of this revetment it will, however, be necessary during the coming season to make extensive repairs in the pockets which have developed by caving and threaten the destruction of the work. To make complete repairs will require about 2,700 feet of continuous mattress work.

The continuous revetment in Ashport Bend, extending some 16,540 feet in length, is generally in good condition. A small break in the revetment, caused by a caving pocket, was repaired during the past season. Some damage has been done by the recent flood in the enlargement of pockets in the upper bank, which will probably require repairs in the way of paving in the near future.

Fletchers Bend revetment, covering a length of some 17,700 feet of bank, was partially repaired during the season by means of a mat 771 feet long, 250 feet wide, and 1,856 square yards of bank paving. The high stage of river prevented the completion of the repairs contemplated during the past season. The recent flood has developed further defects in this revetment, and it is probable that repairs to the extent of 1,000 feet or more in length will be required during the coming season.

The revetment at the head of Osceola Bar, 3,750 feet in length, was constructed in 1895. This was for the purpose of preventing a break into the old chute between upper and lower Osceola Bar. The bank above this revetment began caving in 1900 and extended down to and behind the upper end of the revetment, and increased at such a rapid rate that before repairs were made nearly half of the revetment had been destroyed.

During the past season attempts were made to repair this revetment, but the high water prevented the accomplishment of this work. A mat 637 feet long, 250 feet wide, was constructed and the usual precautions taken for holding the same; but the accumulation of drift and the rapid caving carried the mat away and the work was lost. Some 1,500 feet of the old revetment still remains in good condition, but the restoration of the work will require the construction of some 1,200 feet of new work during the coming season. The revetment work along the middle and lower Osceola bars is apparently in good condition.

The Bullerton Bar revetment, some 10,000 feet in length, which was constructed in 1893–94, is still in good condition and has required no repairs since its completion.

It may be well to note that the excessive repairs called for in this reach are largely confined to the old type of mattress work, which was deficient in width and weak in construction.

Abattis, or experimental dikes.—These dikes are used for the purpose of closing secondary chutes and to contract the low-water channels by building up the sand bars. During the past season 2,810 linear feet of dike were put in opposite Hathaways Landing, Tenn. (183 R.) The river at this point forms two channels around the middle bar, and the purpose of the dike was to induce the filling of one of these channels by deposits. This dike was constructed with considerable difficulty, due to high stage of water, drift, and running ice. The result attained by this dike can not be fully ascertained until after the passing of the present high stage of river. Investigations of the dikes previously constructed—the Cherokee, Ashport Bar, Elmot Bar—all show that they have been quite effective in the increase of the bar areas.

For further details concerning this reach, see the reports of Captain Lucas and Assistant Engineer Nolty, appended hereto.

Second district, foot of Island 40 to White River (175 miles).—Headquarters, 280 Second street, Memphis, Tenn. District officers: Capt. E. Eveleth Winslow to October 31, 1902, and from October 31, 1902, Capt. E. W. Van C. Lucas.

Hopefield Bend, Ark., 227 to 230 miles below Cairo, right bank.—This revetment is about 16,600 feet in length and extends from Mound City chute to Hopefield Point, and is essential to the maintenance of deep water in the Memphis Harbor. It was constructed at various times between 1882 and 1889, and has been repaired from time to time since its completion. The flood of this year destroyed some 2,400 feet of the earlier work at the upper end of Hopefield Bend, and damaged a considerable length of the upper-bank work of the later revetment. That portion of the bank protected by the later form of fascine mattresses shows no sign of failure, although subject to the attacks of an unusually strong current during the late flood. It will be necessary to renew a portion of this revetment which has been destroyed and make minor repairs to the remainder of the work. This work is essential to the preservation of Memphis Harbor.

Wolf River, 230 miles below Cairo, left bank.—This work relates also to Memphis Harbor and embraces the maintenance by dredging of a navigable channel to the county bridge, 2½ miles above the mouth of Wolf River. During the past season dredging to the amount of 42,250 cubic yards of material was done. A channel was also blasted through a ledge of sand rock and cemented gravel, which had been uncovered by previous dredging. The ledge was about 200 feet in width, and at its highest point was less than 2 feet below low water. A cut 25 to 40 feet in width and 3 feet in depth was made through the ledge by drilling and blasting. Although the stage of water was exceedingly low during the season, a navigable channel was easily maintained. To maintain this channel dredging will be required during each low-water season.

Memphis Harbor, 230 miles below Cairo, left bank.—The work along the Memphis front embraces the protection of 14,800 linear feet of bank by means of spur and continuous revetment. The upper portion of the revetment is covered by a sand bar which encroaches somewhat on the levee front of Memphis. The area of this bar between Wolf River and the levee front is about 106 acres at low water, 8 acres of which is above water at the 25-foot stage. Investigations show little or no increase in the height of this bar during the year 1902. After the recession of the present high water investigations will be made to ascertain the changes caused by this flood. There has been little or no extension of the bar downstream since 1896. The revetment along the Memphis front is in good condition, no repairs having been made during the past season, and none are contemplated for the coming season.

Helena, Ark., 306 miles below Cairo, right bank.—The revetment work at this point consists of the protection of 4,900 linear feet of river bank in front of the city. Part of this is continuous revetment and part consists of submerged spur dikes. During the past season slight caving occurred between the spur dikes and also some settlement along the lower revetment, due to the return flow of ground water accumulating behind the levees. To remedy this trouble a series of ditches filled with brush and stone were put in for the purpose of facilitating the drainage. The defects shown in the revetment at this point threaten the destruction of the levee, which is very near the top of the bank. It will therefore be necessary to make such repairs during the coming season as will prevent further deterioration of this revetment.

The shortage of plant and scarcity of labor made the amount of work done in the first and second districts much less than was contemplated and also served to increase the cost of all work that was carried out.

For further details concerning the work in the second district, see reports of Captain Lucas and Assistant Engineer Rees, herewith.

Third district, from the Coahoma-Bolivar county line, on the left bank (365 miles below Cairo) and mouth of White River on the right bank (393 miles below Cairo), to Warrenton, Miss. (607 miles below Cairo), left bank.—Headquarters, Randolph Building, Memphis, Tenn. District officer: Capt. C. L. Potter, Corps of Engineers, U. S. Army.

In this district are included the works of improvement at the upper end of Lake Bolivar, Mississippi, Ashbrook Neck, Mississippi, Greenville Harbor, Mississippi, Louisiana Bend, Louisiana, Lake Providence, La., and Delta Point, Louisiana.

The operations of the past year have included repairs to the revetments at Lake Bolivar, Ashbrook Neck, Greenville, and Lake Providence.

Lake Bolivar front, 417 miles below Cairo, left bank.—The revetment at this point was built to hold a bank whose caving threatened the destruction of a levee extending across between the head of Lake Bolivar and the bank of the river, the destruction of which would result in the abandonment of a large area of highly cultivated land. The original work constructed in 1888–89 covered 4,250 linear feet of the bank. Slight repairs have been made at different times to the upper bank paving. The revetment is now in good condition and has satisfactorily served the purpose for which it was constructed. With the exception of minor repairs necessary to keep this revetment in order, no further work is contemplated at this point.

Ashbrook Neck, 446 miles below Cairo, left bank.—The object of the work at this point was to prevent a threatened cut-off which would have seriously disturbed the regimen of the river for a long distance both above and below and brought disaster to towns, levees, and other works along the river banks. Work was begun in 1890 and continued at intervals until 1895. Repairs have been made from time to time by means of renewals of the upper bank paving and pocket mats where a subsidence of the revetment developed. The bank line has been effectually held throughout the whole distance of about 11,000 feet covered by the revetment, which is still in fairly good condition. It is, however, important to maintain this revetment with such repairs as may be needed from time to time.

Greenville Harbor, 478 miles below Cairo, left bank.—This work has for its object the rectification of the banks to prevent the encroachment of the river upon the town of Greenville, and also to prevent the destruction of the controlling levee line which protects the Yazoo Basin from overflow. During the twelve years from 1882 to 1894 the recession of the bank in the Greenville Bend amounted to 4,000 feet. This work was begun in 1887, when ten submerged dikes were put in. The plan was changed to continuous revetment in 1891, and the work was extended at various times until the length covered now amounts to about 14,500 feet. During the past year minor repairs were made to the upper bank paving, and also pocket mats were placed at the upper end to prevent the current from cutting in behind the head of the work. Since the completion of this work the bank line has been effectually maintained. The revetment is in good condition, but will need constant care in order to maintain its efficiency.

Lake Providence Reach, 517–552 miles below Cairo.—Prior to the improvement work this reach presented the most serious obstructions to low-water navigation of any portion of the river below Cairo, except perhaps the Plum Point Reach. The depths were often as low as 4½ to 5 feet on the crossings. It was therefore selected by the Commission as one of the reaches where a project for systematic improvement should be carried out. The works in this reach resulted in a decided improvement in the channel depths, but they proved to be too light to long withstand the ravages of the floods. Revetment was for a time prohibited by Congressional enactment, appropriations failed, and the repairs and renewals deemed necessary to strengthen and hold the work already done could not be made, and in consequence of this the uncompleted works were badly wrecked. It may, however, be said that these works served a useful purpose by materially improving the navigation of the entire reach, which still continues much better than it was before the work was begun. There has been but one low-water season since the works approached a stage of completion when the channel depth was not sufficient for the demands of navigation, and even during that season the depth was some two feet greater than the common low-water depths prior to the beginning of the improvement work.

Louisiana Bend, 522 miles below Cairo, right bank.—The revetment in this bend is part of the systematic improvement of Lake Providence Reach. Work began in 1889 and was continued from time to time as funds were available up to 1897. No extension or repair of this work has been made since that date. The total length of the original work was 15,820 feet, a considerable portion of the lower end of which has been destroyed by the floods.

Lake Providence, 540 miles below Cairo, right bank.—The object of the revetment work along the Lake Providence front has been to control and hold a rapidly caving bank that threatened to destroy the town of Lake Providence and an important levee situated between the lake and the bank of the river. The destruction of this levee would necessitate the building of a long new line of levee, extending from

Bunch's Bend levee around the lower end of Lake Providence, and would result in the abandonment of several square miles of cultivated land, and probably also leave a portion of the town of Lake Providence outside of the levee. This revetment work was begun in 1894 and continued during the following year. Further extensions were made in 1899 and 1900, the total length now being about 12,800 feet. Minor breaks have developed at different times and the repairs of these have been necessary. Some defects have recently developed in the line of this revetment, and repairs will doubtless be required during the coming season. It is, however, important that this work should be maintained both for the purpose of preserving the present levee line and also for the rectification of the channel.

Delta Point, 598 miles below Cairo, right bank.—The object of this work has been to hold the point opposite Vicksburg and prevent the recession of the channel downstream away from the harbor, and the work, therefore, really forms a part of the improvement of Vicksburg Harbor, which is now in charge of the Engineer Department. No repairs were needed on this work during the past year. The caving above the work may render it necessary to extend the revetment upstream, and provision for this may be required in the near future.

For further details in regard to this district see the reports of Captain Potter and Assistant Engineer Hider hereto appended.

Fourth district, Warrenton, Miss., to Head of Passes, 607-1,060 miles below Cairo.—Headquarters, 3232 Prytania street, New Orleans, La. District officers: Maj. Geo. McC. Derby up to September 30, 1902, and after that date Capt. Chas. S. Bromwell.

The works include the bank protection of Bondurant Chute, bank protection in Kempe Bend, improvement of the harbors of Natchez and Vidalia, Miss. and La., rectification of the Red and Atchafalaya rivers, and improvement of the harbor of New Orleans, La.

Bondurant Chute, 644 miles below Cairo, right bank.—This work was undertaken in order to prevent the destruction of the levee lying between the end of Lake Bruin and the bank of the river, no other location of the levee line being practicable in the immediate vicinity, and its abandonment would involve the construction of a loop several miles long around behind the lake. In addition to the cost of constructing this new line of levee to replace the old line the abandonment of the latter would result in destroying a large amount of cultivated land.

This revetment consists of mattresses constructed of lumber for the submerged portion with upper bank paving of concrete. During the past year the revetment has been extended 600 feet downstream, making a total length of 2,200 feet. It is now in good condition and has served to prevent further erosion of the bank. Some extension and minor repairs are contemplated during the coming season.

Kempe Bend, 658 miles below Cairo, right bank.—The object of this work has been to prevent further erosion of the bank line in Kempe Bend, which had already destroyed several lines of levee and nearly reached an important line the destruction of which would necessitate a long line of new levee of difficult construction and therefore unusually expensive. The construction of a new line would also involve a considerable period of time and a break in the front line in the meantime would be very disastrous to a large section of the country below Kempe. Work on this revetment was begun in 1899 and continued during each season since that time and it now reaches a length of 5,480 feet of continuous revetment.

During the past season the work was extended 600 feet downstream and 850 feet upstream. In front of an exposed segment of the levee, about 4,800 feet above the upper end of the revetment, a detached revetment 850 feet long was also placed. The stage of water does not admit of a careful inspection, but the work is believed to be in fairly good condition. In this bend several classes of upper bank paving are being tried. In all cases the bank is graded to the usual slope and is then covered with brick, concrete, or broken blocks of concrete. The details of this work are given in annual report of Chief of Engineers for 1900, page 4913. As it is a radical departure from former work, its efficiency is watched with more than usual interest. An extension of the revetment will doubtless be required during the coming season.

Harbors of Natchez and Vidalia, 688 miles below Cairo, left bank.—This work consists of the revetment of Giles Bend in order to prevent a threatened cut-off which would not only disturb the general regimen of the river for a long distance, but would probably destroy the harbors of Natchez and Vidalia. This work now covers a length of about 14,000 feet, some 2,200 of which was constructed during the past season. All of this work has been effective in maintaining the bank line where the construction has been completed. A further extension of the work and minor repairs will be required during the coming season. The levee built along Cowpen Neck in conjunction with this work has also been maintained. Operations at this point have generally been carried on under special appropriations, and a continuance of them is deemed advisable.

Junction of the Mississippi, Red, and Atchafalaya rivers, 764 miles below Cairo.—The improvement of this locality consists in the maintenance of mattress sills in the Atchafalaya River for the purpose of preventing the enlargement of the stream, and also dredging of the Old River for the purpose of maintaining an adequate channel between the Mississippi, Red, and Atchafalaya rivers. The work during the past season has been confined to the widening of sill dam No. 3, by means of an apron mattress placed on the upstream side of the dam. The original sills were placed in 1887–88, and since that time no enlargement of the Atchafalaya has been observed. The dams are apparently in good condition, and beyond the slight repairs necessary to maintain them no further work is contemplated in this section. During the past season the depth of water in lower Old River was such that no dredging was required at any time. The physical changes in this vicinity are carefully measured by means of frequent surveys, as it is very important to ascertain any marked tendency to enlargement of the Old River or the head of the Atchafalaya. The great importance of maintaining the present conditions requires that sufficient funds should be reserved to check any tendency toward enlargement and keep these localities at all times under complete control. The effect of the contraction of section caused by recent construction of railway embankments has not as yet been ascertained.

New Orleans Harbor, 936 miles below Cairo, left bank.—The object of the work in this harbor is to prevent the erosion of banks and consequent loss and damage to adjacent property. The work consists mainly of spur dikes placed at intervals of about 450 feet. In places where the erosion was specially active, continuous revetment was placed between these spurs. The banks are protected in Carrollton Bend, at the upper end of the harbor, in the vicinity of Southport; in Greenville Bend opposite Audubon Park, Gouldsboro Bend, Algiers

Point, and in the Third district. A total of something like 18,000 linear feet of bank is thus protected by dikes and continuous revetment. During the past season the Southport work was extended 715 feet upstream, and the project contemplated the extension of the work downstream as well, but the high stage of the river necessitated the suspension of the work until the coming season. The steep banks and great depth of water make the rectification of the banks in New Orleans Harbor both difficult and expensive, and the danger of sudden collapse in certain localities is by no means remote. The original project contemplated some 50,000 feet of revetment, about one-third of which has been placed. Under the conditions here found it is of more than ordinary importance that ample means should be provided for the extension and completion of the revetment necessary to make the river banks along the city front reasonably safe.

For further details concerning the work in this district, see the reports of Captain Bromwell and Assistant Engineer Douglas, hereto appended.

SURVEYS AND OBSERVATIONS IN THE DISTRICTS.

First and Second districts.—The surveys in these districts consisted of the general survey of the Memphis Reach, from Island 40 to the Memphis railroad bridge, including a detailed survey of Memphis Bar and Hopefield Bend. A survey was also made of the caving bank in the vicinity of Mound City. A general survey of Plum Point Reach from Island 26 to Fort Pillow was made, including detailed surveys to determine the effect of the abattis dikes at Ashport Bar and Elmot Bar. A topographical survey was also made for an extension of the Walnut Bend levee to Wheel Ridge. High-water surveys of levees were made to obtain data relative to the flood of 1903.

Third district.—Surveys in the Third district were made of the Lake Providence Reach from Homochitto to Lake Providence, and also along the several banks which have been revetted. The caving bends at Carters and Caulks necks were also surveyed to ascertain the extent of the erosion and the danger of cut-offs at these points.

Fourth district.—In this district surveys were made at Kempe Bend, Giles Bend, Atchafalaya sill dams, and the works in New Orleans Harbor. Limited surveys have also been made in the localities where erosion of banks has been active.

PLANT.

All of the plant in charge of the secretary of the Commission has been cared for, when not in use, at West Memphis, Ark. The steamer *Mississippi* was docked at New Orleans, and inspection of the hull developed some defects which will necessitate repairs in the way of replating a portion of the hull during the coming season. New rudders and steam steering gear will also be installed.

The floating plant which is now used chiefly for the surveys consists of the steamer *Patrol* and quarterboat *Illinois*, together with a number of yawls and skiffs. The boilers of the *Patrol* have been repaired and tested and the quarterboat *Illinois* generally overhauled and repaired.

The dredge *Alpha* has been entirely dismantled, as the machinery was too light and the capacity of the dredge too small for effective work in the field.

The dredge *Beta* was employed at South Pass during the season of

1902 and was again called for in January, 1903, and at the present time this dredge is in the hands of the engineer officer in charge of work at South Pass.

Such repairs have been made to the remaining seven dredges as were found necessary to keep them in thorough working order.

Plans for a new self-propelling dredge are in course of preparation. The towboats used as dredge tenders have all received minor repairs, and the rebuilding of the upper works of the *Wynoka* is now in progress at Howard's yards. The inspection steamer *Search* is undergoing repairs, consisting chiefly of a new hull. The small tenders, pile sinkers, and barges have all received the repairs necessary to keep them in serviceable condition.

The plant belonging to the First and Second districts is located a short distance below Memphis when not in active service. At the beginning of the last season the plant was in bad condition and the appropriation became available so late in the season that only such repairs as were imperatively needed to put the revetment plant in order were undertaken. General repairs have been made to barges and steamers during the past winter. Extensive repairs will be required to the two towboats *Chisca* and *Titan*, and further funds will be needed to complete the equipment with sufficient plant for a vigorous prosecution of the field work during the coming year. No new plant has been purchased or built for this district since 1894.

Third district.—The plant pertaining to the third district is cared for at Greenville, Miss., when not in use. The repairs were confined to such work as was necessary to keep the plant in working order. Much of the plant is now in bad condition and will require extensive repairs during the coming season. A new towboat has been contracted for and 12 new barges will be constructed. This, together with the repairs contemplated, will restore the plant to good working condition.

Fourth district.—The plant pertaining to this district is cared for at Natchez and at New Orleans. General repairs to the entire plant have been made, and it is on the whole in fairly good condition. During the year two steel-hull tugboats were purchased and ten new barges are now under contract.

LEVEES.

At the eighty-sixth session of the Commission in June, 1902, the following allotments were made from the appropriation contained in the river and harbor act approved June 13, 1902, to be expended on levees during the fiscal year ending June 30, 1903:

FIRST AND SECOND ENGINEER DISTRICTS.

Reelfoot levee district	$20,000
Lower St. Francis levee district	125,000
White River levee district	90,000
Upper Yazoo levee district	70,000
	305,000

THIRD ENGINEER DISTRICT.

Upper Tensas levee district	$112,500
Lower Yazoo levee district	291,000
	403,500

FOURTH ENGINEER DISTRICT.

Lower Tensas levee district	$110,000
Atchafalaya levee district	40,000
Lafourche levee district	20,000
Barataria levee district	10,000
Pontchartrain levee district	101,500
Lake Borgne levee district	10,000
	291,500

At the eighty-seventh session of the Commission, in November, 1902, the following sums were made available for levee contracts, payable out of the appropriation to be made in the sundry civil bill of March 3, 1903, for the fiscal year ending June 30, 1904:

FIRST AND SECOND ENGINEER DISTRICTS.

Upper St. Francis levee district	$20,000
Reelfoot levee district	20,000
Lower St. Francis levee district	125,000
White River levee district	90,000
Upper Yazoo levee district	70,000
	325,000

THIRD ENGINEER DISTRICT.

Upper Tensas levee district	$112,500
Lower Yazoo levee district	291,000
	403,500

FOURTH ENGINEER DISTRICT.

Lower Tensas levee district	$110,000
Atchafalaya levee district	40,000
Lafourche levee district	20,000
Barataria levee district	10,000
Pontchartrain levee district	81,500
Lake Borgne levee district	10,000
	271,500

The levees of the first and second engineer districts, comprising the following levee districts—Upper St. Francis, Missouri; Reelfoot, Kentucky and Tennessee; Lower St. Francis, Missouri and Arkansas; Upper Yazoo, Mississippi, and White River, Arkansas—were, until October 31, 1902, in charge of Capt. E. E. Winslow, Corps of Engineers, U. S. Army, who at that time was relieved by Capt. E. W. Van C. Lucas, Corps of Engineers, U. S. Army.

The Upper St. Francis levee district extends, on the right bank, from Birds Point, Missouri, opposite Cairo, to the mouth of Bayou St. John, just above New Madrid, with a river frontage of 70 miles and an area of 700 square miles. The complete protection of this district depends upon a levee outside of the jurisdiction of the Commission, from Birds Point up to the high land in the vicinity of Cape Girardeau. This line is incomplete and in bad repair.

The length of line projected by the Commission is 54 miles, of which 5.4 miles have been built.

At the end of the fiscal year the United States had erected 287,198, and the local authorities 98,700, or a total of 385,898 cubic yards. During the fiscal year ending June 30, 1904, the United States will expend $20,000 and the local authorities $10,000.

The yardage estimated as necessary for completion is 5,076,650.

The Reelfoot levee district extends, on the left bank, from Hickman, Ky., to Slough Landing, Tennessee, with a river frontage of 24 miles and an area of 318 square miles. The levee line projected has a length of 20 miles, of which the 4½ miles in Tennessee, containing 440,710 cubic yards, have been built by the local authorities and 2.13 miles at the upper end, or 141,912 cubic yards, by the United States, during the fiscal year ending June 30, 1903. It is proposed by the Commission to expend $20,000 and by the local authorities to build about 2.9 miles during the fiscal year ending June 30, 1904. The present contents is 582,622 and that estimated for completion is about 1,700,000 cubic yards.

The Lower St. Francis levee district extends, on the right bank, from Point Pleasant, Mo., to the mouth of the St. Francis River, with a river frontage of 219 miles and an area of 3,500 square miles. The projected levee has a total length of 210 miles. An upper section of 166 miles, and a detached part of 12 miles, have been jointly built by the United States and local authorities. There remains to be built the gap of 17 miles between these two sections and an extension of 15 miles at the lower end. The contents at the end of the last fiscal year was 13,997,681, of which 9,588,814 cubic yards have been built by the local authorities. During the present fiscal year there has been erected by the United States 287,887 cubic yards. It is proposed by the Commission, during the coming fiscal year, to construct 560,000 cubic yards at a cost of $125,000 and by the local levee districts to expend $500,000.

It is estimated that 10,217,000 cubic yards will be required for the completion of the levee system of this district.

The White River levee district extends from Helena, Ark., 64 miles down the right bank. The area is 910 square miles. The line is complete in length with the exception of four breaks out of the 14 caused by the flood of 1897, which have been kept open until the grade and section of the rest of the line shall have been sufficiently improved. Their aggregate length is 10,000 feet.

The improvement during the present fical year included the construction of 163,241 cubic yards by the United States and 47,566 by the local authorities.

The contents existing at the end of the last fiscal year was 7,538,218 cubic yards, of which 6,085,484 were placed by the United States, and it is proposed to expend $90,000 in improvement during the coming year. The estimate for completion is 8,680,000 cubic yards.

The Upper Yazoo levee district extends on the left bank with a river frontage of 121 miles from the hills south of Horn Lake, Tennessee, below Memphis, to the lower Coahoma line. Its levee has a length of 120 miles and protects an area of 3,281 square miles.

At the end of the last fiscal year there were in the system 20,168,531 cubic yards of earthwork, of which 14,053,545 cubic yards had been placed by the local authorities. It is estimated that 6,800,000 cubic yards are required for its standard completion. During the present fiscal year the Government added 128,947 and the local authorities 575,400 cubic yards. During the next fiscal year an expenditure of $70,000 is proposed by the Commission.

For more complete details concerning the condition and needs of the levees in the foregoing districts and the flood of 1903 reference is made to the reports of Capt. E. W. Van C. Lucas, Corps of Engineers, U. S. Army, and of his assistant engineers, A. J. Nolty, W. M. Rees, Chas. Le Vasseur, and M. Gardner, Appendix 2, and to the communications of Mr. T. G. Dabney and Mr. H. N. Pharr, chief engineers of the Upper Yazoo and the Lower St. Francis levee districts, Appendixes C. and A.

The levees of the third engineer district, comprising the Lower

Yazoo, Mississippi, and Upper Tensas, Arkansas and Louisiana, levee districts, are in charge of Capt. C. L. Potter, Corps of Engineers, U. S. Army.

The Lower Yazoo levee district extends, on the left bank, from the upper line of Bolivar County, Miss., to the mouth of the Yazoo River above Vicksburg, with a river frontage of 227 miles and an area of 3,367 square miles. The length of the levee line is 188.34 miles. The contents at the end of this fiscal year is about 33,263,691 cubic yards, of which 17,440,625 were built by the United States. Of this the United States placed during the year 1,004,258 and the local authorities 482,391 cubic yards. During the coming fiscal year the Commission proposes to expend $291,000, but owing to the great cost to the local authorities of the high-water fight of 1903 it is improbable that they will be able to contribute their usual share to the improvement.

The estimated quantity required for the completion of the line to an ultimate grade is 14,485,458 cubic yards.

The Upper Tensas levee district extends, on the right bank, from the higher lands on the south side of the Arkansas River to a point in Louisiana opposite Warrenton, with a river frontage of 180 miles and an area of about 2,875 square miles. The length of the levee line is 186.7 miles. Its present contents is 29,092,868 cubic yards, of which 21,956,421 have been placed by the United States. During the present fiscal year the United States has added 269,563, and the local authorities 453,587 cubic yards. A considerable extension at the upper end is required to complete the line. The Commission's allotment for the coming fiscal year is $112,500, to which the States of Arkansas and Louisiana will make material additions.

For more detailed information concerning the condition and requirements of the levees in these districts and the flood of 1903 reference is made to the reports of Capt. C. L. Potter, Corps of Engineers, U. S. Army, and of Asst. Engineers Arthur Hider, A. M. Todd, and E. C. Tollinger, Appendix 3, and of Mr. C. H. West and Mr. H. B. Richardson, chief engineers of the Lower Yazoo levee district and of the State of Louisiana, Appendixes B and D.

The levees of the fourth engineer district, comprising the Lower Tensas, Atchafalaya, Lafourche, Barataria, Pontchartrain, and Lake Borgne districts, all in Louisiana, were in charge of Maj. Geo. McC. Derby, Corps of Engineers, U. S. Army, until September 30, 1902, when he was relieved by Capt. Chas. S. Bromwell, Corps of Engineers, U. S. Army.

The Lower Tensas levee district extends, on the right bank, in continuation of the Upper Tensas, from a point opposite Warrenton, Miss., to the mouth of Red River, Louisiana, with a river frontage of 155 miles and an area of 2,080 square miles. The length of constructed levee is 135.28 miles, but an extension at the lower end of about 15 miles is projected. At the end of the last fiscal year the levees of the district contained 17,208,698 cubic yards. To this has been added by the United States 505,524 and by the State of Louisiana 335,111 cubic yards. It is proposed by the Commission to expend $110,000 in the improvement of the levees of the district during the coming year.

The Atchafalaya levee district extends, on the right bank, from the Red River to Bayou Lafourche, with a river frontage and levee system on the right bank about 122 miles long. The area protected is 6,085 square miles. At the end of the last fiscal year the contents was 18,888,943 cubic yards, to which during the present year the State of Louisiana added 680,135 and the United States 122,852 cubic yards.

An allotment of $40,000 has been made for this district for the fiscal year ending June 30, 1904.

The Lafourche and Barataria levee districts extend, on the right bank, from Bayou Lafourche to the Head of the Passes, omitting the city of New Orleans. The river front is 160.5 miles. The levees terminate at The Jump, with a length of 149.5 miles. The area protected is 2,020 square miles. The cubic yards of earthwork in these levees on June 30, 1902, was 10,704,120, to which during the present fiscal year 122,852 were added by the United States, and 531,709 by the local authorities. An allotment of $30,000 has been made for the coming year.

The Pontchartrain and Lake Borgne levee districts extend, on the left bank, from Baton Rouge to the Head of the Passes, exclusive of the city of New Orleans, a distance of 214.5 miles. The levees are 193.5 miles long and terminate at Fort St. Philip. They protect an area of 1,816 square miles. The contents at the end of the last fiscal year was 16,182,340, to which the United States during the present fiscal year added 678,257 and the State 258,011 cubic yards. The allotment for the coming year is $91,500.

For more complete details concerning the condition and needs of the levees in the foregoing districts reference is made to the reports of Capt. C. S. Bromwell, Corps of Engineers, U. S. Army, and of Asst. Engineer W. E. Knobloch, Appendix 4, and to the communication of Mr. Henry B. Richardson, chief engineer of Louisiana, Appendix D.

The following tabulated statement gives the condition of levees and of levee work at the end of the present fiscal year:

Levee districts.	In system.	Built.	Contents in 1902.	Built since by United States.	Built since by local authorities.	Constructed in 1903.
	Miles.	*Miles.*	*Cubic yds.*	*Cubic yds.*	*Cubic yds.*	*Cubic yds.*
Upper St. Francis	54	5.4	385,898	....	....	385,898
Reelfoot	20	5.1	440,710	141,912	....	582,622
Lower St. Francis	210	178	13,997,681	287,887	....	14,285,568
White River	64	62	7,538,218	163,241	47,566	7,749,025
Upper Yazoo	124	124	20,168,531	128,947	575,400	20,872,878
Lower Yazoo	188.34	188.34	32,128,994	1,004,258	482,391	33 615,643
Upper Tensas	194	186.7	28,579,698	269,563	453,587	29,302,848
Lower Tensas	150	135	17,208,698	505,524	335,111	18,049,333
Atchafalaya	122	122	18,888,943	122,852	680,135	19,691,930
Lafourche	78	78	7,828,036	....	511,756	8,339,792
Barataria	71.5	71.5	2,876,084	12,285	19,953	2,908,322
Pontchartrain	123.5	123.5	13,900,807	611,830	191,122	14,703,759
Lake Borgne	70	70	3,281,538	66,427	66,889	3,414,854
Total	1,469.34	1,349.54	167,223,836	3,314,726	3,368,910	173,902,472

Levee districts.	Lost during year.	Contents in 1903.	Required to complete.	Estimated final contents.	Percentage now built.
	Cubic yards.	*Cubic yards.*	*Cubic yards.*	*Cubic yards.*	
Upper St. Francis	....	385,898	5,076,650	5,462,548	0.071
Reelfoot	....	582,622	1,722,792	2,305,414	.253
Lower St. Francis	320,470	13,965,098	10,532,583	24,497,681	.570
White River	30,060	7,718,965	8,919,253	16,638,218	.464
Upper Yazoo	....	20,872,878	6,795,653	27,668,531	.754
Lower Yazoo	373,187	33,242,456	13,434,970	46,677,426	.712
Upper Tensas	210,000	29,092,848	16,235,638	45,328,486	.642
Lower Tensas	102,250	17,947,083	10,883,989	28,831,072	.622
Atchafalaya	280,000	19,411,930	5,339,408	24,751,338	.784
Lafourche	213,920	8,125,872	2,662,850	10,788,722	.753
Barataria	28,454	2,879,868	1,526,159	4,406,027	.654
Pontchartrain	125,000	14,578,759	4,460,013	19,038,772	.765
Lake Borgne	12,200	3,402,654	1,496,089	4,898,743	.695
Total	1,695,541	172,206,931	89,086,047	261,292,978	.659

It will be observed from this table that the loss of existing levees during the year by abandonment on account of caving banks, from crevasses, and other causes is 1,695,541 cubic yards, or a little less than 1 per cent of the contents. The amount during the fiscal year ending June 30, 1902, was three-fourths of 1 per cent and for the six years previous to 1902 did not exceed an annual average of two-thirds of 1 per cent. It may be reasonably assumed that the yardage required to close a gap caused by a caving bank or a crevasse will be about double the amount actually lost, indicating for eight years an annual cost of maintenance of 1½ per cent. It should also be stated in connection with this table that a full examination of the phenomena presented by the last flood will lead to a revision of the grades heretofore provisionally recommended and, consequently, of the estimated final contents of the levees on some parts of the river, and that these changes will probably involve some increase of grades and contents. The extent of this can not yet be determined.

The flood of 1903 culminated at Cairo on March 15, a rather earlier date than usual. It reached the stage of 50.6, within 1.57 feet of the highest known, and which had only been exceeded five times since the establishment of the Cairo gauge in 1871. The volume was largely increased below the Ohio by the St. Francis, White, Arkansas, Yazoo, and Red rivers and all the minor tributaries, which were without exception at extremely high stages in time to meet and increase the volume from above. This is particularly true of the Red River, where the flood was of very unusual height and duration. The discharge in 1903 was greater than that in 1898, particularly in the lower part of the river, but less throughout than that in 1897.

Comparing the heights reached in 1903 with those reached in 1897, they were less from Cairo for a distance of about 115 miles to near Cottonwood Point, the greatest excess in the earlier year being about 2 feet. From above Cottonwood Point to below Commerce, a distance of 265 miles, the stage in the later year was higher, the greatest excess being about 3 feet at Memphis. Below Commerce the high-water planes again crossed each other and the 1897 record was higher nearly to Friars Point, or for a distance of about 40 miles, the general difference being about 1 foot. From thence to Rescue the lines of the two years repeatedly coincided or crossed each other, the difference seldom exceeding five-tenths of a foot. As the mouth of the St. Francis is approached the stage of 1903 fell below that of 1897, the difference being eight-tenths of a foot at Helena; but before reaching Sunflower the lines had crossed again, the later year having an ascendency of 0.83 foot at that gauge station. At the head of the Lower Mississippi levee district the difference was about the same, and thence continued with an excess ranging up to 2 feet at certain places, down to Catfish Point, where it was reduced for a distance of 7 or 8 miles (at Moores), to about a quarter of a foot. From here it suddenly increased in 5 miles to over 4 feet as the result of the Huntington Short Line. It is most remarkable that this change of line, which precipitated a fall of over 1 foot in 2,000 along the levee on the left bank, caused no change of slope along the levees of the opposite shore.

From this point—about opposite Arkansas City—the difference steadily continued above the record of 1897 as far down as Brunswick. Thence to the end of the Mississippi levee system it was about 1 foot lower; at Vicksburg 0.7; at St. Joseph and Natchez, respectively, 0.15 and 0.58 higher; at Red River 0.6 lower; at Bayou Sara 0.25, at Baton Rouge 0.65, at Plaquemine 0.15, at Donaldsonville 0.55, and at College Point 0.15 lower. Between this gauge station and Carrollton 1903 again recovered the ascendency, being 0.23 higher at Carrollton and 0.80 at Fort Jackson than in 1897.

The prematurity of the maximum gauge readings at these two stations, discussed by Major Derby in the report of 1900, was again observed this year.

The following table gives a comparison of the heights in the two years under consideration at the permanent gauge stations:

High-water records.

Gauges.	Below Cairo.	Standard high water.	Highest before 1903.	Highest in 1903.	1903 compared with standard.	1903 compared with previous highest.
	Miles.					
Cairo	....	54.17	52.17	50.60	−3.57	−1.57
Columbus	21.3	48.10	45.58	44.40	−3.70	−1.18
New Madrid	70.3	42.90	41.50	39.50	−3.40	−2.00
Cottonwood Point	122.5	42.20	39.35	40.00	−2.20	+0.65
Fulton	175.4	40.40	38.30	40.10	−0.30	+1.80
Memphis	230.0	41.60	37.66	40.60	−1.00	+3.00
Mhoon	276.3	46.20	41.60	41.80	−4.40	+0.20
Helena	306.5	54.10	51.75	51.00	−3.10	−0.75
Sunflower	352.7	50.20	47.17	48.00	−2.20	+0.83
White River	393.2	56.40	52.42	53.70	−2.70	+1.28
Arkansas City	438.3	56.30	51.90	53.00	−3.30	+1.10
Greenville	478.3	50.50	46.75	49.10	−1.40	+2.35
Lake Providence	542.3	48.00	44.54	46.40	−1.60	+1.86
Vicksburg	599.3	55.00	52.48	51.80	−3.20	−0.68
St. Joseph	648.3	50.80	47.85	48.00	−2.80	+0.15
Natchez	700.3	54.00	49.82	50.40	−3.60	+0.58
Red River Landing	765.3	52.50	50.20	50.00	−2.50	−0.20
Bayou Sara	799.3	45.70	43.70	43.40	−2.30	−0.30
Baton Rouge	833.3	43.20	40.65	40.00	−3.20	−0.65
Plaquemine	854.1	38.70	36.25	36.10	−2.60	−0.15
Donaldsonville	885.4	34.95	32.75	32.20	−2.75	−0.55
College Point	904.5	29.80	27.95	27.80	−2.00	−0.15
Carrollton	957.0	20.35	19.17	19.40	−0.95	+0.23
Fort Jackson	1,039.0	8.00	7.20	8.00	0.00	+0.80

It is probable that from the experience herein recorded a revision of the standard heights at some parts of the river will be required to meet the conditions imposed by the improvement of levees, and that this revision will involve some increase in the yardage required for completion. But it will be impossible to prepare this in time for this report.

The differences in gauge and slope between the two years compared can all be explained by reference to changes in the alignment of levees, to their extension reducing the overflow into the basins, and to the great improvement in grade and section during the past six years. As might have been expected, it is very observable that the marked increase in stage during the later year was along the mid-fronts of the basins and not at or about the confluence of the tributaries, where there was generally a reduction.

Notwithstanding the greater flood heights recorded in 1903, there was a very great reduction in the number of crevasses and in the resulting overflow. During the flood of 1897 there occurred in the St. Francis Basin thirteen crevasses, aggregating 13,405 feet in length. This year there were two, whose combined length was 2,945 feet. It has been the reasonable policy of the local levee authorities of this basin to make the most rapid extension possible of the levee line, with a view of giving protection in years of moderate flood to the greatest area. The grade of these advanced levees has been generally not more than 2 feet above previous high waters. The funds allotted by the Commission have been used in following this State work, raising the grade and enlarging the section. Both of the crevasses mentioned, at Random Shot and Hollybush, were in these advanced State levees, which enlargement by the United States had not reached.

In the Upper Yazoo Basin there was in 1897 a disastrous crevasse at Flower Lake. The district this year was exempt from disaster.

In 1897 there were fourteen crevasses in the White River district, with an aggregate length of 16,400 feet This year there were none, although four of the breaks of the earlier flood remained unclosed.

The Lower Yazoo district was the scene of five crevasses in the flood of 1897, with an aggregate length of 8,860 feet. Lagrange and Albemarle were the only two crevasses this year, and they attained a combined width of 4,975 feet. The cause of the Lagrange crevasse is unknown, but its result was disastrous. On the other hand, the Albemarle was clearly the result of deficient grade and section. It was so near the lower end of the system that it added but little to the overflow, as the lands behind the levee were already submerged by backwater entering through the opening left at the lower end of the basin for the exit of its drainage through the Yazoo River.

Three crevasses occurred in the Upper Tensas district in 1897. Their aggregate length was 3,830 feet. During the present flood there was but one, at Hollybrook, with a width of 3,400 feet. As this occurred after the water had fallen 2 feet, it can be attributed to an abatement of vigilance. The only crevasse in the system of the Lower Tensas levee district in 1897 was at Glasscock, with a width of 1,400 feet. This year there was none, but the lower end of the existing line was washed away, thus increasing the backwater overflow from Red River. In each year there was one crevasse between Red River and New Orleans, but this year, owing to the increased height of 0.8, there were three small and unimportant breaks on the left bank between that city and the end of the levee system.

In discussing the damage done by an overflow a clear distinction should be drawn between its three sources. First, from backwater at the lower end of the basins through the openings left for their drainage. This can be limited by the downward extension of levees, but can not be entirely prevented. Second, through unbuilt parts of the levee system; and third, through crevasses. This distinction has not been observed in previous reports, and in this and subsequent reports it may be difficult to make an exact division. Whatever overflow occurred this year in the Upper St. Francis and Reelfoot districts was entirely attributable to the second of these sources, as only a commencement has been made in the construction of their levees. In the Lower St. Francis Basin, of which the area to be protected is 3,500 square miles, the overflow attributed to backwater and incomplete levees was about 1,015 square miles, and to the two crevasses, about 215 square miles. Of the area overflowed about 90 square miles were cultivated. The local levee engineers estimate that "The entire damage done to all interests amounts approximately to $500,000."

In the White River Basin the overflow was from the four breaks remaining unclosed after the flood of 1897. It extended over 768 square miles of the 910 included in the basin. Information concerning the proportion of cultivated land and the amount of damages is not now available.

As before reported, the Upper Yazoo Basin was entirely free from overflow this year.

Of the area of 3,367 square miles in the Lower Yazoo Basin, about 1,460 square miles are overflowed, of which approximately half, or 730 miles, was attributable to the first source or back water from the Yazoo River, and the rest from the Lagrange crevasse. Of the flooded area about 500 square miles were in cultivation.

Of the 2,875 square miles in the Upper Tensas Basin, 500 were overflowed from the second source mentioned or the unbuilt opening in the levees at the head of the system. The overflow from the Hollybrook crevasse was about 800 square miles, of which 72 were cultivated.

The overflow in the Lower Tensas Basin, containing 2,080 square miles, was almost exclusively from the back water at the lower end of the system. The increase from the Hollybrook crevasse in the district was slight. The area submerged was about 1,325 square miles, of which 46 were in cultivation.

The Atchafalaya Basin, containing 6,085 square miles, escaped entirely without overflow, as did also the Pontchartrain Basin, with an area of 1,816 square miles, except at the extreme lower end, where three small breaks flooded 16 square miles, of which 2½ were in cultivation.

The Hymelia crevasse occurred in the Lafourche Basin, containing 2,020 square miles. The crevasse water covered about 1,320 square miles, of which at least 1,300 were sea marsh, low swamp, or lakes and other water surface, leaving less than 20 square miles in cultivation inundated.

The result of the flood may be tabulated as follows:

Area of overflow in 1903.

Districts.	Contents.	Overflow from back water.	Overflow from unbuilt lines.	Overflow from crevasses.	Cultivated.	Total overflowed.
	Sq. miles.	*Sq. miles.*	*Sq. miles.*	*Sq. miles.*	*Sq. miles.*	*Sq. miles.*
Upper St. Francis	700	0	275	0	(a)	275
Reelfoot	318	0	310	0	(a)	310
Lower St. Francis	3,500	515	500	215	90	1,230
White River	910	384	384	0	(a)	768
Upper Yazoo	3,281	0	0	0	0	0
Lower Yazoo	3,367	730	0	730	500	1,460
Upper Tensas	2,875	0	500	800	72	1,300
Lower Tensas	2,080	1,275	0	0	46	1,275
Atchafalaya	6,085	0	0	0	0	0
Lafourche and Barataria	2,020	0	0	1,320	20	1,320
Pontchartrain and Lake Borgne	1,816	0	0	16	2.5	16
Total	26,952	2,904	1,969	3,081	730.5	7,954

[a] Unknown.

It is altogether probable that the overflow water receded from those lands devoted to the cultivation of cotton and of rice in time for the planting of this year's crop.

The following table gives the amount of those damages of the overflow of this year to the levee system which can be directly estimated:

Districts.	Repair of breaks.	Emergency expenditures.		Total.
		By United States.	By local authorities.	
Upper St. Francis	....	....	....	....
Reelfoot	....	$155	....	$155
Lower St. Francis	$18,000	29,498	$35,794	83,292
White River	0	21,628	9,760	31,388
Upper Yazoo	0	466	26,000	26,466
Lower Yazoo	56,000	4,039	105,332	165,371
Upper Tensas		14,221	68,934	83,155
Lower Tensas				
Atchafalaya				
Lafourche	152,615	84,853	297,000	483,968
Barataria				
Pontchartrain				
Lake Borgne				
Total	226,615	104,380	542,820	873,795

To this must be added a very large amount for wave wash and other repairs of flood damage, and many items furnished by private parties and counties or parishes. Among the other damages to the property protected by levees, and of which no estimate can be made, may be enumerated buildings, fences, drainage, stock, crops, the dispersion of labor and the general suspension of trade, commerce, and the postal service. The only district in which an estimate has been made by the local authorities is the Lower St. Francis, in which it amounts to $500,000. If this serves as a basis of estimate which may be extended to the other districts, the aggregate damage from this year's flood is $5,000,000.

The past flood established, more clearly than has any previous one, both the importance and the practicability of a complete and sufficient levee system. In its present condition, incomplete both as regards extension and dimensions, it gave substantial protection to three-quarters of the alluvial valley and its interests, which under equal flood conditions without levees would have been a lake from 20 to 80 miles wide from Cairo to the Gulf. The improvement made during the past six years has reduced the number of crevasses between Cairo and New Orleans from 38 to 6. Of the area overflowed this year five-eighths was the direct result of back water from the lower ends of the basins and overflow through unbuilt parts of projected lines, and only three-eighths from breaks in the levees, notwithstanding their unfinished condition as regards both grade and section.

Under these circumstances the importance of the earliest practicable completion of the work is apparent. If the flood damages of 1903 may be approximately estimated at $5,000,000, the previous expenditure of that sum in permanent work would have largely if not entirely prevented them. Every year's delay in completion incurs the risk of similar loss. When the system shall have been completed the cost will have been increased by many millions of dollars, and the development of the valley delayed by many years of anxiety and disaster, which could have been saved by continuous work on a scale commensurate with the importance and magnitude of the improvement. The State levee districts realize this. Most of them have anticipated their revenues as far as practicable, and several have now under consideration plans for such increase of resources applicable to the work as will shorten the time of completion. The

Commission is so impressed with this view of the subject that it considers it for the best interests of the work to now make contracts for levee construction to the extent of $2,000,000, as provided for in the river and harbor act of June 13, 1902, from the amounts to be appropriated for the fiscal years ending June 30, 1905, and June 30, 1906. Furthermore, it suggests that if Congress should think proper to make additional provision for levee construction during the fiscal years ending June 30, 1905, and June 30, 1906, the sum of $2,000,000 in addition to the amounts already provided can be judiciously and advantageously expended during each year.

Respectfully submitted.

O. H. Ernst,
Colonel, Corps of Engineers, U. S. Army,
President Mississippi River Commission.
B. M. Harrod,
Robt. S. Taylor,
Henry L. Marindin,
Assistant, Coast and Geodetic Survey.
J. A. Ockerson,
H. M. Adams,
Lieut. Col., Corps of Engineers, U. S. Army.
Thos. L. Casey,
Major, Corps of Engineers, U. S. Army.

Brig. Gen. G. L. Gillespie,
Chief of Engineers, U. S. A.

Money statements.

Appropriations expended under Mississippi River Commission.

[Appropriation for improving Mississippi River.]

July 1, 1902, balance unexpended		$2,645,651.03
Amount appropriated by sundry civil act approved March 3, 1903	$2,000,000.00	
Miscellaneous receipts from transfers and sales of engineer property under the provisions of section 5 of river and harbor act of June 13, 1902	905.16	
		2,000,905.16
		4,646,556.19
June 30, 1903, amount expended during fiscal year		1,679,886.16
July 1, 1903, balance unexpended		2,966,670.03
July 1, 1903, outstanding liabilities	$55,768.19	
July 1, 1903, amount covered by uncompleted contracts	455,936.25	
		511,704.44
July 1, 1903, balance available		2,454,965.59
Distributed as follows:		
Mississippi River Commission		13,727.67
Surveys, gauges, and observations		11,722.48
Levees		172,489.80
Revetment and contraction works, permanent channel improvements and protection		41,763.09
Dredges and dredging		151,326.67
Experimental dikes		1,016.43
Plant and miscellaneous		94,382.87
Improving harbors and tributaries		94,922.23
Unallotted		1,873,614.35
		2,454,965.59

Amounts necessary to be appropriated for the fiscal year ending June 30, 1905, in addition to the balance unexpended July 1, 1903.

For continuing the improvement of the Mississippi River from Head of the Passes to the mouth of the Ohio River, including salaries and clerical, office, traveling, and miscellaneous expenses of the Mississippi River Commission	$2,000,000.00
Improving harbor at Memphis, Tenn. (including Wolf River)	75,000.00
Improving harbor at Natchez, Miss., and Vidalia, La	150,000.00
Rectification of Red and Atchafalaya rivers, Louisiana	20,000.00
Improving harbor at New Orleans, La	300,000.00
	2,545,000.00

[Appropriation for gauging the waters of the Lower Mississippi and its tributaries.[a]]

July 1, 1902, balance unexpended	$320.00
Amount allotted by Chief of Engineers, July 23, 1902, from permanent indefinite appropriation made by section 6 of river and harbor act of August 11, 1888, as amended by section 9 of river and harbor act of June 13, 1902	9,100.00
	9,420.00
June 30, 1903, amount expended during fiscal year	7,878.64
July 1, 1903, balance unexpended	1,541.36
July 1, 1903, outstanding liabilities	654.47
July 1, 1903, balance reverting to Treasury	886.89
Amount that can be profitably expended in fiscal year ending June 30, 1905, in addition to the balance unexpended July 1, 1903	9,600.00

[Appropriation for waterway from Lockport, Ill., to St. Louis, Mo.]

Amount appropriated by river and harbor act approved June 13, 1902	$25,000.00
June 30, 1903, amount expended during fiscal year	7,472.48
July 1, 1903, balance unexpended	17,527.52
July 1, 1903, balance available	17,527.52

Consolidated statement of all appropriations expended under the Mississippi River Commission to June 30, 1903.

[Appropriation for improving Mississippi River.]

Act of June 28, 1879 (organic)	$175,000.00
Act of June 16, 1880 (sundry civil)	150,000.00
Act of March 3, 1881 (river and harbor)	1,000,000.00
Act of March 3, 1881 (sundry civil)	150,000.00
Act of August 2, 1882 (river and harbor)	4,123,000.00
Act of August 7, 1882 (sundry civil)	150,000.00
Act of March 3, 1883 (sundry civil)	150,000.00
Act of January 19, 1884 (river and harbor)	1,000,000.00
Act of July 5, 1884 (river and harbor)	75,000.00
Act of July 5, 1884 (river and harbor), less $5,000 transferred to snagboat service	2,065,000.00
Act of July 7, 1884 (sundry civil)	75,000.00
Act of August 5, 1886 (river and harbor), less $5,942.60 for expenses, office Chief of Engineers	1,994,057.40

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[a] The custody and care of the gauges maintained under this appropriation were assumed by the Mississippi River Commission February 11, 1901, on which date they were transferred to the secretary, under authority of Secretary of War, dated January 25, 1901.

Act of August 5, 1886 (river and harbor), less $47.30 for expenses, office Chief of Engineers		$29,952.70
Act of August 11, 1888 (river and harbor), less $4,859 for expenses, office Chief of Engineers		2,840,141.00
Act of August 11, 1888 (river and harbor)		75,000.00
Act of October 2, 1888 (sundry civil)		35,000.00
Act of October 19, 1888 (deficiency), less $4,214.39 reverted to the Treasury		20,785.61
Act of September 19, 1890 (river and harbor)		3,200,000.00
Act of September 30, 1890 (deficiency)		5,625.00
Act of March 3, 1891 (deficiency)		1,950.00
Act of March 3, 1891 (joint resolution)		1,000,000.00
Act of July 13, 1892 (river and harbor)		2,470,000.00
Act of July 28, 1892 (deficiency)		44.80
Act of March 3, 1893 (sundry civil)		2,665,000.00
Act of August 18, 1894 (river and harbor)		485,000.00
Act of August 18, 1894 (sundry civil)		2,665,000.00
Act of March 2, 1895 (sundry civil)		2,665,000.00
Act of June 3, 1896 (river and harbor)		909,000.00
Joint resolution approved March 31, 1897 (Public, No. 6)		250,000.00
Act of June 4, 1897 (sundry civil)		2,933,333.00
Act of July 19, 1897 (deficiency)		625,000.00
Act of July 1, 1898 (sundry civil)		1,983,333.00
Act of March 3, 1899 (sundry civil)		2,583,333.00
Act of March 3, 1899 (river and harbor)		185,000.00
Act of June 6, 1900 (sundry civil), less $5,000 for expenses, office Chief of Engineers		2,245,000.00
Act of June 13, 1902 (river and harbor)		90,000.00
Act of June 13, 1902 (river and harbor)		2,200,000.00
Act of March 3, 1903 (sundry civil)		2,000,000.00
Total specific appropriations		45,269,555.51
Balances from former appropriations applied to works Below Cairo under act of August 2, 1882, less $123.42 reverted to Treasury	$272,504.96	
Same for works above Cairo, under act of July 5, 1884	22,632.53	
Total balances		295,137.49
Miscellaneous receipts:		
Reimbursement for Engineer property transferred by authority of Secretary of War under the provisions of sections 5 of river and harbor act of June 13, 1902 (taken up by secretary in April, 1902, under allotment for "Dredges and Dredging")	250.00	
Receipts from sale of condemned Engineer property under the provisions of section 5 of river and harbor act of June 13, 1902 (taken up by fourth district officer in September, 1902, under allotment for "Plant")	540.81	
Receipts from sale of condemned Engineer property under the provisions of section 5 of river and harbor act of June 13, 1902 (taken up under unallotted balance)	114.35	
Amount received from Quartermaster's Department, United States Army, September 21, 1898, on account reimbursement for plant loaned during war of 1898 and lost at sea (taken up by fourth district officer in January, 1899)	8,000.00	
Total miscellaneous receipts		8,905.16
Total		45,573,598.16

EXPENDED.

Location and object.	To June 30, 1902.	During year ending June 30, 1903.	Total.
Mississippi River Commission	$641,568.44	$32,653.84	$674,222.28
Surveys, gauges, and observations	1,933,314.66	81,449.94	2,014,764.60
Levees	16,580,614.87	694,019.65	17,274,634.52
Revetment and contraction works, permanent channel improvements and protection	10,146,344.37	265,156.39	10,411,500.76
Dredges and dredging	2,779,904.61	236,147.65	3,016,052.26
Experimental dikes	84,000.00	14,885.50	98,885.50
Plant and miscellaneous	1,736,329.67	189,496.33	1,925,826.00
Improving harbors and tributaries	6,289,904.52	163,505.16	6,453,409.68
Works above Cairo	735,060.83	2,571.70	737,632.53
Total expended	40,927,041.97	1,679,886.16	42,606,928.13
Balance unexpended June 30, 1903			1,093,055.68
Unallotted			1,873,614.35
Total appropriated, etc			45,573,598.16

[Appropriation for gauging the waters of the Lower Mississippi and its tributaries.]

Allotments from general appropriations for examinations, surveys, and contingencies of rivers and harbors by acts of—	
March 3, 1871	$5,000.00
June 10, 1872	5,000.00
March 3, 1873	5,000.00
June 23, 1874	5,000.00
March 3, 1875	5,000.00
Specific appropriations by river and harbor acts of—	
August 14, 1876	5,000.00
June 18, 1878	5,000.00
March 3, 1879	5,000.00
June 14, 1880	5,000.00
March 3, 1881	5,000.00
August 2, 1882	5,000.00
Deficiency act of March 12, 1884	2,100.00
Specific appropriations by river and harbor acts of—	
July 5, 1884	5,000.00
August 5, 1886	5,000.00
Allotted from specific appropriation by river and harbor act of August 11, 1888	8,700.00
Deficiency act of October 19, 1888	3,600.00
Allotments from permanent indefinite appropriation made by section 6 of river and harbor act of August 11, 1888, for fiscal years, viz:	
1890	9,000.00
1891 (less $3,518.34 withheld in United States Treasury under ruling that only $6,000 can be expended each fiscal year)	5,181.66
1892	5,100.00
1893	5,500.00
1894	5,500.00
1895	5,500.00
1896	5,500.00
1897	5,500.00
1898	5,500.00
1899	6,000.00
1900	5,500.00
1901	6,000.00
1902	6,000.00
Allotment from permanent indefinite appropriation made by section 6 of river and harbor act of August 11, 1888, as amended by section 9 of river and harbor act of June 13, 1902	9,100.00
Total	164,281.66

EXPENDED.

	To June 30, 1902.	During year ending June 30, 1903.	Total.
Expenditures	$147,389.79	$7,878.64	$155,268.43
Unexpended balances reverted to Treasury	7,471.87	886.89	8,358.76
Total	154,861.66	8,765.53	163,627.19
Unexpended balance June 30, 1903			654.47
Total appropriated, etc			164,281.66

[Appropriation for waterway from Lockport, Ill., to St. Louis, Mo.]

Act of June 13, 1902 (river and harbor)	$25,000.00
Expenditures to June 30, 1903	7,472.48
Unexpended balance June 30, 1903	17,527.52
Total appropriated, etc	25,000.00

Consolidated statement of condition of appropriations and allotments under Mississippi River Commission on June 30, 1903.

SECRETARY MISSISSIPPI RIVER COMMISSION.

[Appropriations: Improving Mississippi River; gauging the waters of the lower Mississippi and its tributaries.]

	Appropriation for improving Mississippi River, allotment for—				
	Mississippi River Commission.	Surveys, gauges, and observations.	Dredges and dredging.	Expended allotments.	Total.
Amount expended on previous projects	$238,110.74	$855,247.37			$1,093,358.11
Amount expended on present project to end of last fiscal year	403,457.70	799,946.77	$2,389,300.50	[a]$46,131.14	3,638,836.11
Balance unexpended at end of last fiscal year	81.30	11,988.56	112,393.80		124,413.66
Amount appropriated or allotted since (net)	47,000.00	69,000.00	[b]345,250.00		461,250.00
	47,031.30	80,988.56	457,643.80		585,663.66
Amount expended from beginning of present fiscal year to end of previous month	30,044.62	57,008.31	217,537.89		304,590.82
Amount expended during month	2,609.22	10,042.93	18,609.76		31,261.91
	32,653.84	67,051.24	236,147.65		335,852.73
Balance unexpended at end of month	14,377.46	13,937.32	221,496.15		249,810.93
In Treasury United States	11,931.56	8,580.69	170,722.10		191,234.35
In hand	2,445.90	5,356.63	50,774.05		58,576.58
	14,377.46	13,937.32	221,496.15		249,810.93
Outstanding liabilities at end of month	649.79	2,488.97	26,819.48		29,958.24
Amount covered by existing contracts at end of month		199.70	43,350.00		43,549.70
	649.79	2,688.67	70,169.48		73,507.94
Balance available at end of month	13,727.67	11,248.65	151,326.67		176,302.99

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[a] Experimental dikes, $45,075.58; patrol of the Mississippi River, $1,055.56.

[b] Includes $50,000 allotted from the appropriation by sundry civil act of March 3, 1903, by resolution of Mississippi River Commission March 30, 1903 (Proc., p. 856), approved by Secretary of War April 16, 1903 (147-62 Sec. M. R. C.).

Consolidated statement of condition of appropriations and allotments under Mississippi River Commission on June 30, 1903—Continued.

SECRETARY MISSISSIPPI RIVER COMMISSION—Continued.

	Appropriation for gauging the waters of the lower Mississippi and its tributaries.	Appropriation for waterway from Lockport, Ill., to St. Louis, Mo.	Grand total.
Amount expended on previous projects			$1,093,358.11
Amount expended on present project to end of last fiscal year	$147,389.79		3,786,225.90
Balance unexpended at end of last fiscal year	320.00		124,733.66
Amount appropriated or allotted since (net)	9,100.00	$25,000.00	495,350.00
	9,420.00	25,000.00	620,083.66
Amount expended from beginning of present fiscal year to end of previous month	6,302.84	7,466.65	318,360.31
Amount expended during the month	1,575.80	5.83	32,843.54
	7,878.64	7,472.48	351,203.85
Balance unexpended at end of month	1,541.36	17,527.52	268,879.81
In Treasury United States		15,000.00	206,234.35
In hand	1,541.36	2,527.52	62,645.46
	1,541.36	17,527.52	268,879.81
Outstanding liabilities at end of month	654.47		30,612.71
Amount covered by existing contracts at end of month			43,549.70
	654.47		74,162.41
Balance available at end of month	[a] 886.89	17,527.52	194,717.40

[a] Balance of $886.89 reverts to Treasury.

WORKS ABOVE CAIRO.

[Appropriation: Improving Mississippi River.]

	Protection near Cairo.[a]	Des Moines Rapids to Ohio River.	Total.
Amount expended on present project to end of last fiscal year	$47,428.30	$687,632.53	$735,060.83
Balance unexpended at end of last fiscal year	2,571.70		2,571.70
Amount expended from beginning of present fiscal year to end of previous month	2,571.70		2,571.70

[a] Includes only work under act of July 5, 1884.

Consolidated statement of condition of appropriations and allotments under Mississippi River Commission on June 30, 1903—Continued.

FIRST AND SECOND DISTRICTS.

[Appropriations: Improving Mississippi River; repairing Government levee at Walnutbend, Ark.]

	Improving Mississippi River, allotment for—				
	Surveys.	Lower St. Francis levee district.	White River levee district.	Reelfoot levee district.	Upper Yazoo levee district.
Amount expended on present project to end of last fiscal year	$104,054.06	$891,853.70	$1,191,521.08	....	$1,158,804.66
Balance unexpended at end of last fiscal year	119.05	10,073.30	4,213.52	....	7,547.12
Amount appropriated or allotted since (net)	5,000.00	125,000.00	90,000.00	$20,000.00	70,000.00
	5,119.05	135,073.30	94,213.52	20,000.00	77,547.12
Amount expended from beginning of present fiscal year to end of previous month	5,072.53	78,674.31	54,765.22	17,983.16	27,220.42
Amount expended during the month	....	2,746.47	1,610.35	158.13	5,964.85
	5,072.53	81,420.78	56,375.57	18,141.29	33,185.27
Balance unexpended at end of month	46.52	53,652.52	37,837.95	1,858.71	44,361.85
In Treasury United States	....	50,000.00	21,000.00	....	44,361.85
In hand	46.52	3,652.52	16,837.95	1,858.71	....
	46.52	53,652.52	37,837.95	1,858.71	44,361.85
Outstanding liabilities at end of month	46.52	586.20	600.00	98.99	500.00
Amount covered by existing contracts at end of month	....	53,066.32	37,190.81	1,759.72	35,322.19
	46.52	53,652.52	37,790.81	1,858.71	35,822.19
Balance available at end of month	....	....	47.14	....	8,539.66

	Improving Mississippi River, allotment for—				
	Plum Point Reach.	Dikes.	Plant.	At Hickman, Ky.	At New Madrid, Mo.
Amount expended on present project to end of last fiscal year	$5,055,968.63	$38,924.42	$795,701.56	$94,255.22	$150,209.09
Balance unexpended at end of last fiscal year	691.99	....	3,998.42	876.78	1,790.91
Amount appropriated or allotted since (net)	70,000.00	16,000.00	[a] 124,000.00	....	....
	70,691.99	16,000.00	127,998.42	876.78	1,790.91
Amount expended from beginning of present fiscal year to end of previous month	67,776.36	14,885.50	78,418.17	72.65	....
Amount expended during the month	137.63	....	8,494.47	....	....
	67,913.99	14,885.50	86,912.64	72.65	....
Balance unexpended at end of month	2,778.00	1,114.50	41,085.78	804.13	1,790.91
In Treasury United States	....	....	35,000.00	....	....
In hand	2,778 00	1,114.50	6,085.78	804.13	1,790.91
	2,778.00	1,114.50	41,085.78	804.13	1,790.91
Outstanding liabilities at end of month	200.00	50.00	10,000.00	....	....
Amount covered by existing contracts at end of month	693.30	48.07	9,500.00	....	....
	893.30	98.07	19,500.00	....	....
Balance available at end of month	1,884.70	1,016.43	21,585.78	804.13	1,790.91

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[a] Includes $15,000 allotted from the appropriation by sundry civil act of March 3, 1903, by resolution of Mississippi River Commission March 26, 1903 (proceedings, p. 853), approved by Secretary of War, April 16, 1903.

Consolidated statement of condition of appropriations and allotments under Mississippi River Commission on June 30, 1903—Continued.

FIRST AND SECOND DISTRICTS—Continued.

	Improving Mississippi River, allotment for—				
	Caruthersville, Mo.	Hopefield Bend (preservation of works at).	At Memphis, Tenn.	At Helena, Ark.	Improving harbor at Memphis, Tenn. (Wolf River).
Amount expended on present project to end of last fiscal year	$54,998.57	$127,692.07	$44,622.10	$200,109.52	
Balance unexpended at end of last fiscal year	1.43	2,307.93	377.90	390.48	
Amount appropriated or allotted since (net)	20,000.00			5,000.00	$10,000.00
	20,001.43	2,307.93	377.90	5,390.48	10,000.00
Amount expended from beginning of present fiscal year to end of previous month	19,613.23			3,607.08	6,272.45
Amount expended during the month					
	19,613.23			3,607.08	6,272.45
Balance unexpended at end of month	388.20	2,807.93	877.90	1,783.40	3,727.55
In Treasury United States					2,000.00
In hand	388.20	2,307.93	377.90	1,783.40	1,727.55
	388.20	2,307.93	377.90	1,783.40	3,727.55
Outstanding liabilities at end of month	178.98			183.40	
Amount covered by existing contracts at end of month	209.22				
	388.20			183.40	
Balance available at end of month		2,307.93	377.90	1,000.00	3,727.55

	Improving Mississippi River, allotment for—		Repairing Government levee at Walnutbend, Ark.	Grand total.
	Expended allotments.	Total.		
Amount expended on present project to end of last fiscal year	a$2,108,953.78	$11,817,668.46		$11,817,668.46
Balance unexpended at end of last fiscal year		32,388.83	$90,000.00	122,388.83
Amount appropriated or allotted since (net)		555,000.00		555,000.00
		587,388.83	90,000.00	677,388.83
Amount expended from beginning of present fiscal year to end of previous month		374,361.08	1,286.06	375,647.14
Amount expended during the month		19,111.90		19,111.90
		393,472.98	1,286.06	394,759.04
Balance unexpended at end of month		193,915.85	88,713.94	282,629.79
In Treasury United States		152,361.85	88,000.00	240,361.85
In hand		41,554.00	713.94	42,267.94
		193,915.85	88,713.94	282,629.79
Outstanding liabilities at end of month		12,444.09		12,444.09
Amount covered by existing contracts at end of month		137,789.63		137,789.63
		150,233.72		150,233.72
Balance available at end of month		43,682.13	88,713.94	132,396.07

[a] Preservation of works, $54,867.89; removal of Nonconnah rock, $9,000; dredges and dredging, $388,097.12; Columbus, Ky., $43,750; improving St. Francis River (Walnutbend levee), $75,000; preservation of works at Walnutbend levee, $28,200; improving harbor at Memphis, Tenn., $1,425,038.77; improving harbor at Memphis, Tenn. (Wolf River), $45,000; Upper St. Francis levee district, $40,000.

Consolidated statement of condition of appropriations and allotments under Mississippi River Commission on June 30, 1903—Continued.

THIRD DISTRICT.

[Appropriation: Improving Mississippi River.]

	Improving Mississippi River, allotment for—				
	Surveys, gauges, and observations.	Lower Yazoo levee district.	Upper Tensas levee district.	Ashbrook Neck.	Lake Providence Reach.
Amount expended on present project to end of last fiscal year	$82,929.82	$2,917,013.06	$4,277,300.05	$567,466.64	$3,769,143.11
Balance unexpended at end of last fiscal year	....	13,229.33	10,357.75	....	9,500.57
Amount appropriated or allotted since (net)	5,000.00	291,000.00	112,500.00	35,000.00	....
	5,000.00	304,229.33	122,857.75	35,000.00	9,500.57
Amount expended from beginning of present fiscal year to end of previous month	4,176.17	175,419.91	66,801.41	33,566.61	9,177.44
Amount expended during the month	150.00	2,905.91	5,043.72	337.63	25.67
	4,326.17	178,325.82	71,845.13	33,904.24	9,203.11
Balance unexpended at end of month	673.83	125,903.51	51,012.62	1,095.76	297.46
In Treasury United States	....	86,000.00	37,500.00	....	....
In hand	673.83	39,903.51	13,512.62	1,095.76	297.46
	673.83	125,903.51	51,012.62	1,095.76	297.46
Outstanding liabilities at end of month	200.00	1,000.00	800.00	18.42	123.81
Amount covered by existing contracts at end of month	....	104,000.00	30,000.00	1,077.34	173.65
	200.00	105,000.00	30,800.00	1,095.76	297.46
Balance available at end of month	473.83	20,903.51	20,212.62	....	....

	Improving Mississippi River, allotment for—					
	Stone.	General repairs to existing works.	Plant.	Greenville, Miss.	Expended allotments.	Total.
Amount expended on present project to end of last fiscal year	$234,494.80	....	$806,572.55	$878,115.57	[a]$774,339.02	$14,307,374.12
Balance unexpended at end of last fiscal year	5,505.20	....	10,527.90	....	....	49,120.75
Amount appropriated or allotted since (net)	50,000.00	$50,000.00	[b]107,000.00	25,000.00	....	675,500.00
	55,505.20	50,000.00	117,527.90	25,000.00	....	724,620.75
Amount expended from beginning of present fiscal year to end of previous month	21,316.12	33,305.67	30,471.23	17,200.48	....	391,435.04

[a] Lake Bolivar front, $145,358.04; improving harbor at Vicksburg, Miss., $442,724.77; Delta Point, La., $186,256.21.

[b] Includes $42,000 allotted from the appropriation by sundry civil act of March 3, 1903, by resolution of the Mississippi River Commission, March 26, 1903 (proc., p. 853), approved by Secretary of War April 16, 1903.

Consolidated statement of condition of appropriations and allotments under Mississippi River Commission on June 30, 1903—Continued.

THIRD DISTRICT—Continued.

	Improving Mississippi River, allotment for—					
	Stone.	General repairs to existing works.	Plant.	Greenville, Miss.	Expended allotment.	Total.
Amount expended during the month	$3,270.34	$7,634.68	$5,942.15	$165.95	....	$25,476.05
	24,586.46	[a]40,940.35	36,413.38	17,366.43	....	416,911.09
Balance unexpended at end of month	30,918.74	9,059.65	81,114.52	7,633.57	....	307,709.66
In Treasury United States	28,000.00	9,059.65	74,000.00	....	....	234,559.65
In hand	2,918.74	....	7,114.52	7,633.57	....	73,150.01
	30,918.74	9,059.65	81,114.52	7,633.57	....	307,709.66
Outstanding liabilities at end of month	100.00	....	8,000.00	....	....	10,242.23
Amount covered by existing contracts at end of month	....	....	25,000.00	396.73	....	160,647.72
	100.00	....	33,000.00	396.73	....	170,889.95
Balance available at end of month	30,818.74	9,059.65	48,114.52	7,236.84	....	136,819.71

[a] Lake Bolivar front, $9,942.72; Ashbrook Neck, $13,309.81; Greenville, Miss., $3,437.50; Lake Providence Reach. $18,250.32.

FOURTH DISTRICT.

[Appropriations: Improving Mississippi River; improving harbor of Natchez and Vidalia, Miss. and La.; improving harbor of New Orleans, La.; improving Atchafalaya and Red rivers, Louisiana.]

	Improving Mississippi River, allotment for—				
	Surveys, gauges, and observations.	Lower Tensas levee district.	Atchafalaya levee district.	Lafourche levee district.	Barataria levee district.
Amount expended on present project to end of last fiscal year	$91,137.14	$2,445,002.79	$1,401,018.82	$548,947.55	$331,652.76
Balance unexpended at end of last fiscal year	....	13,046.15	24,090.84	7,536.37	3,080.11
Amount appropriated or allotted since (net)	5,000.00	110,000.00	40,000.00	20,000.00	10,000.00
	5,000.00	123,046.15	64,090.84	27,536.37	13,080.11
Amount expended from beginning of present fiscal year to end of previous month	4,964.43	[a]89,180.14	29,193.94	9,180.08	4,467.57
Amount expended during the month	35.57	9,231.39	962.30	507.65	46.51
	5,000.00	98,411.53	30,156.24	9,687.73	4,514.08
Balance unexpended at end of month	....	24,634.62	33,934.60	17,848.64	8,566.03
In Treasury United States	....	18,000.00	30,000.00	10,000.00	3,500.00
In hand	....	6,634.62	3,934.60	7,848.64	5,066.08
	....	24,634.62	33,934.60	17,848.64	8,566.08
Outstanding liabilities at end of month	....	42.32	17.05	9.34	47.85
Amount covered by existing contracts at end of month	....	11,129.29	30,695.00	15,121.99	3,269.58
	....	11,171.61	30,712.05	15,131.33	3,317.43
Balance available at end of month	....	13,463.01	3,222.55	2,717.31	5,248.60

[a] Amount formally reported reduced 5 cents on account of refundment.

Consolidated statement of condition of appropriations and allotments under Mississippi River Commission on June 30, 1903—Continued.

FOURTH DISTRICT—Continued.

	Improving Mississippi River, allotment for—				
	Pontchartrain levee district.	Lake Borgne levee district.	Bondurant.	Kempe Bend revetment.	Plant.
Amount expended on present project to end of last fiscal year	$1,105,678.38	$291,718.02	$20,000.00	$307,954.26	$138,000.00
Balance unexpended at end of last fiscal year	17,156.10	3,482.11	....	22,045.74	....
Amount appropriated or allotted since (net)	101,500.00	12,000.00	10,000.00	60,000.00	[a] 133,540.81
	118,656.10	15,482.11	10,000.00	82,045.74	133,540.81
Amount expended from beginning of present fiscal year to end of previous month	91,363.77	13,651.41	10,000.00	82,045.74	62,473.13
Amount expended during the month	5,645.28	9.69	....	....	3,697.18
	97,009.05	13,661.10	10,000.00	82,045.74	66,170.31
Balance unexpended at end of month	21,647.05	1,821.01	....	....	67,370.50
In Treasury United States	16,000.00	....	....	....	63,000.00
In hand	5,647.05	1,821.01	....	....	4,370.50
	21,647.05	1,821.01	....	....	67,370.50
Outstanding liabilities at end of month	31.95	281.31	....	....	2,687.93
Amount covered by existing contracts at end of month	13,733.34	....	....	....	40,000.00
	13,765.29	281.31	....	....	42,687.93
Balance available at end of month	7,881.76	1,539.70	....	....	24,682.57

	Improving Mississippi River, allotment for—				
	Natchez and Vidalia harbors, Mississippi and Louisiana.	New Orleans harbor, Louisiana.	Atchafalaya and Red rivers, Louisiana.	Expended Allotments.	Total.
Amount expended on present project to end of last fiscal year	$260,000.00	$18,750.00	....	[b] $136,506.99	$7,091,361.71
Balance unexpended at end of last fiscal year	....	....	....	....	90,437.42
Amount appropriated or allotted since (net)	60,000.00	95,000.00	$15,000.00	....	672,040.81
	60,000.00	95,000.00	15,000.00	....	762,478.23
Amount expended from beginning of present fiscal year to end of previous month	60,000.00	17,371.92	10,490.56	....	484,382.69
Amount expended during the month	....	5,015.67	39.00	....	25,190.24
	60,000.00	22,387.59	10,529.56	....	509,572.93

[a] Includes $22,000 allotted from the appropriation by sundry civil act of March 3, 1903, by resolution of Mississippi River Commission, March 26, 1903 (Proc., p. 853), approved by Secretary of War, April 16, 1903. Includes $504.81, miscellaneous receipts from the sale of condemned engineer property under the provision of section 5 of river and harbor act of June 13, 1902, heretofore reported since September 30, 1902, under head of "Balance unexpended at end of last fiscal year."

[b] Preservation of works, $134,000; dredges and dredging, $2,506.99.

Consolidated statement of condition of appropriations and allotments under Mississippi River Commission on June 30, 1903—Continued.

FOURTH DISTRICT—Continued.

	Improving Mississippi River, allotment for—				
	Natchez and Vidalia harbors, Mississippi and Louisiana.	New Orleans harbor, Louisiana.	Atchafalaya and Red rivers, Louisiana.	Expended allotments.	Total.
Balance unexpended at end of month		$72,612.41	$4,470.44		$252,905.30
In Treasury United States		60,000.00			200,500.00
In hand		12,612.41	4,470.44		52,405.30
		72,612.41	4,470.44		252,905.30
Outstanding liabilities at end of month		5.88			3,123.63
Amount covered by existing contracts at end of month					113,949.20
		5.88			117,072.83
Balance available at end of month		72,606.53	4,470.44		135,832.47

	Improving harbor of Natchez and Vidalia, Miss. and La.	Improving harbor of New Orleans, La.	Improving Atchafalaya and Red rivers, Louisiana.	Grand total.
Amount expended on present project to end of last fiscal year	$282,252.04	$959,421.19	$1,001,709.40	$9,334,744.34
Balance unexpended at end of last fiscal year		20,218.67		110,656.09
Amount appropriated or allotted since (net)				672,040.81
		20,218.67		782,696.90
Amount expended from beginning of present fiscal year to end of previous month		20,218.67		504,601.36
Amount expended during the month				25,190.24
		20,218.67		529,791.60
Balance unexpended at end of month				252,905.30
In Treasury United States				200,500.00
In hand				52,405.30
				252,905.30
Outstanding liabilities at end of month				3,123.63
Amount covered by existing contracts at end of month				113,949.20
				117,072.83
Balance available at end of month				135,832.47

LIST OF APPENDIXES ACCOMPANYING THE ANNUAL REPORT OF THE MISSISSIPPI RIVER COMMISSION FOR THE FISCAL YEAR ENDING JUNE 30, 1903.

Appendix A.

Page.
Letter of H. N. Pharr, chief engineer St. Francis levee district of Arkansas, descriptive of the high water of 1903 (2 plates) 42

Appendix B.

Letter of C. H. West, chief engineer Mississippi levee district, descriptive of the high water of 1903 45

Appendix C.

Letter of T. G. Dabney, chief engineer Yazoo-Mississippi Delta levee district, descriptive of the high water of 1903 48

Appendix D.

Letter of H. B. Richardson, chief engineer State board of Louisiana, descriptive of the high water of 1903 53

Appendix 1.

Report of Capt. Wm. B. Ladue, Corps of Engineers, U. S. Army, secretary Mississippi River Commission, on work in his charge (29 plates) 59
  Money statements 70
  Consolidated statement of appropriations and allotments 71
  Abstract of contracts in force 72
  Commercial statistics 72
  Statement of charts issued and sold 74
  1 A.—Laws affecting the Mississippi River Commission, July 1, 1902, to June 30, 1903 74
  1 B.—Report of Asst. Engineer Geo. H. French on tapeline work and precise leveling, Aitkin, Minn., to Grand Rapids, Minn 74
  1 C.—Report of Asst. Engineer A. T. Morrow on low-water survey, Cairo to Corona Landing, season of 1902 97
  1 D.—Report of Asst. Engineer Kivas Tully on gauges, discharge observations, and office publications 97
  1 E.—Report of Asst. Engineer F. B. Maltby on dredging operations below Cairo 123
  1 F.—Report of Asst. Engineer F. B. Maltby on efficiency tests of dredges (47 plates) 136
  1 G.—Report of Prof. W. B. Gregory on efficiency tests of hydraulic dredges of the Mississippi River Commission 160
  1 H.—Report of Asst. Engineer A. T. Morrow on deep-waterway survey, mouth of Illinois River to St. Louis, Mo 167

Appendix 2.

Report of Capt. E. W. Van C. Lucas, Corps of Engineers, U. S. Army, on operations in First and Second districts (10 plates) 168
  Money statements 187
  Abstract of contracts in force 191
  2 A.—Report of Asst. Engineer A. J. Nolty on works at Hathaways, Caruthersville, and Plum Point Reach 192
  2 B.—Report of Asst. Engineer W. M. Rees on operations in Wolf River, Tennessee, and at Helena, Ark 197
  2 C.—Report of Asst. Engineer A. J. Nolty on care and repair of plant 200
  2 D.—Report of Asst. Engineer A. J. Nolty on operations during high water of 1903 202
  2 E.—Report of Asst. Engineer Chas. Le Vasseur on operations during the high water of 1903 210
  2 F.—Report of Asst. Engineer M. Gardner on operations during the high water of 1903 218

Appendix 3.

Report of Capt. Chas. L. Potter, Corps of Engineers, U. S. Army, on operations in Third district (7 plates) 219
  3 A.—Report of Asst. Engineer Arthur Hider on surveys, revetment work, stone, plant, and high water operations, with report of Geo. C. Thomas, superintendent, appended 227
  3 B.—Report of A. Miller Todd, superintendent, on levees in Lower Yazoo district 244
  3 C.—Report of Asst. Engineer E. C. Tollinger on levees in Upper Tensas district 255
  Money statements 269
  Abstract of contracts in force 271

Appendix 4.

Report of Capt. Chas. S. Bromwell, Corps of Engineers, U. S. Army, on operations in Fourth district (10 plates) 272
4 A.—Abstract of contracts in force May 1, 1903 299
4 B.—Commercial statistics 299
4 C.—Report of Asst. Engineer H. S. Douglas on revetment work 300
4 D.—Report of W. E. Knoblock, superintendent, on levees 314

APPENDIX A.

REPORT OF H. N. PHARR, CHIEF ENGINEER ST. FRANCIS LEVEE BOARD, ON HIGH WATER OF 1903.

OFFICE CHIEF ENGINEER ST. FRANCIS LEVEE DISTRICT OF ARKANSAS,
Memphis, Tenn., May 15, 1903.

SIR: In compliance with the request of your Commission, I am pleased to give you a statement descriptive of the high water of 1903 in the Lower St. Francis levee district and of the condition and needs of the leevee therein.

This district extends from the high land just below New Madrid, Mo., to the mouth of the St. Francis River, just above Helena, Ark., a distance of about 219 miles. The levee line is continuous from the upper end along the right bank of the Mississippi River to Cat Island, about 30 miles below Memphis, a distance of about 168 miles by levee. A gap of 15 miles then exists, which has not been constructed yet, extending from Cat Island to Bledsoe. From Bledsoe to Walnut Bend Landing 17 miles of levee extend. From Walnut Bend Landing to the mouth of the St. Francis River, a distance of about 10 miles, no levee has been constructed. With a continuous levee along the entire front of the district as proposed, protection from overflow will be had to about 3,500 square miles.

This district has been put to great expense and has suffered much damage from high water and flood during this year. The river at Cairo rose above the danger line of 45 feet on the 8th day of March of this year, reached its maximum height of 50.6 feet on that gauge on the 16th and 17th of the same month, and declined to below the danger-line stage on March 28, having remained above the danger-line stage for a period of twenty days.

The highest stage reached of 50.6 feet on the Cairo gauge did not exceed previous high-water records, as several former floods have exceeded this by a foot or more.

The river at Memphis reached the danger line, 33 feet on the gauge, on February 23, and rose to a maximum height of 40.1 feet on March 14, when it began to decline. It receded to below the danger line on April 3, remained below for seventeen days until April 20, when another slight rise reached a stage of 34.4 feet April 27, since which time the fall has been continual.

The maximum stage reached on the Memphis gauge during this flood of 40.1 feet establishes a new maximum high-water reading for the Memphis gauge, being 2.6 feet higher than the previous record established by the flood of 1897. It probably would have gone higher if the levee had not broken previously to that date at Hollybush, 15 miles above Memphis, and at Random Shot, just above Pecan Point.

In spite of all efforts to preserve the levee intact a break from overtopping occurred at upper end of mile 142 at Hollybush Landing at 9 a. m. Monday, March 16; practically the whole of mile 141 was overtopped. Four small breaks, aggregating 2,410 feet, occurred at Hollybush. The damage to the levee by all except the first break is very little, and can be replaced directly in the line of the levee. At the lower break, however, a loop levee around a blue hole will be necessary. In this vicinity the rise of several feet on the crest of the flood was so rapid that it drove the men from the work of topping and sacking the levee at a stage of 39.6 feet on the Memphis gauge. The rapid rise was checked and remained stationary for twenty-four hours after the break at 39.6 feet, when the rise continued and finally reached a maximum of 40.1 feet on the Memphis gauge at 8 a. m. on Friday, March 20, when it began to decline. All of the extensive railroad interests below and west of this break were greatly damaged, and operation of the roads had to be discontinued twenty-four hours after the break occurred on account of washouts and overflow of the track. No trains were run on any of the roads for about two weeks. The agricultural and other interests in the vicinity of Marion were very greatly damaged.

The other break occurred in the levee at Random Shot, 2 miles above Pecan Point at the upper end of mile 109, on Thursday, March 19, at 3 p. m. The levee at this point was about 11 feet high, and was of very deficient cross section, having a 2 to 1 slope with 5-foot crown. For this reason the levee broke before the height of the flood had overtopped it by sloughing on the back side, and "blowing out," though the overflow was about the top of the levee. The break did not widen very rapidly and finally only attained a width of 535 feet. There is an extensive blue hole here which it will be necessary to loop to close the break. The damage done by this break was not as great as the damage done by the Hollybush break, though it was very great.

Information and data have been obtained as far as possible to ascertain the extent of the overflow and damage done the levee district by reason of the two breaks which occurred and from the unfinished gap of about 15 miles in the lower part of the district, and it is thought that about 15 per cent (525 square miles) of the entire levee district (3,500 square miles) was overflowed by reason thereof. A map of the levee district transmitted herewith (Pl. A) shows the extent, force of flow, and area overflowed. Practically 17 per cent of the 525 square miles overflowed, or 90 square miles, is cultivated and the balance is uncultivated. Profiles showing the extent of these two crevasses which occurred, made since the subsidence of the overflow, are also herewith presented (Plate B). The entire damage done to all interests amounts to approximately $500,000.

The recent high water demonstrated the fact that the greater part of the Lower St. Francis levee line is too low and of insufficient dimensions. The high water stood practically at the top of the levee for one-half of its entire length and for many miles was above the top of the levee and was held only by topping the levee with planks, dirt, and sand bags. There is, however, a considerable length of the levee which is as much as 1 to 2 feet above the last high water.

Immediately after the overflow levels were run over the entire length of the levee and the elevations taken of the height of crown and the maximum high-water marks. Profiles have been made and a provisional grade line for future construction has been established 3 feet above the maximum high-water line of the 1903 overflow from the Arkansas-Missouri State line, mile 47, to mouth of Old River, mile 128. From mile 128 the grade increases and reaches a height of 4 feet above at the Choctaw Railroad, mile 151, opposite Memphis. A levee of standard dimensions to this grade is, it seems, as much as can be constructed in the near future with the available funds from all sources. It is thought that this provisional grade is practically as high as the provisional grade heretofore established by the Mississippi River Commission.

From the Choctaw Railroad to the mouth of the St. Francis River the funds available during different years for levee construction in the past have governed very greatly the height of grade for levee construction, and the levee accordingly varies in different localities from Commission grade to 3½ feet below Commission grade.

The following table shows the approximate yardage and cost required to construct the levee in Arkansas to the late provisional grade as established, with the degree of importance:

Table No. 1.

Locality.	Character of work.	Length.	Approximate yardage.	Approximate cost.	Degree of importance.
		Feet.			
Random Shot	New loop	2,835	35,000	$5,250	Urgent.
Cuts	New levee	400	40,000	10,000	Do.
Hollybush	New loop	1,700	94,500	16,065	Do.
		Miles.			
Cat Island-Bledsoe	New work	12	1,750,000	250,000	Do.
Ball Place–Choctaw (Barton Ridge line).	Enlargement and new work.	16½	938,200	126,525	Necessary.
Idaho-Shawnee Village (Golden Lake Back line).	New work	12¼	500,000	80,000	Do.
Luxora-Osceola	Enlargement	5	400,000	50,000	Do.
State Line-Luxora	do	26	1,300,000	208,000	Important.
Osceola-Idaho	do	22	1,100,000	176,000	Do.
Scanlan-Cat Island	do	12	500,000	80,000	Necessary.
Bledsoe-Walnut Bend	do	17	1,070,000	181,900	Advisable.
Walnut Bend—mouth St. Francis.	New work	10	1,760,000	281,600	Do.
Choctaw—mouth St. Francis.	Banquettes	62	700,000	119,000	Do.
State line—Choctaw	do	98½	1,000,000	170,000	Do.
Total			11,187,700	1,754,340	

The following table shows summary of the degree of importance of work contained in the foregoing table and the approximate yardage and cost:

Table No. 2.

Importance of work.	Approximate yardage.	Approximate cost.
Urgent	1,919,500	$281,315
Necessary	2,338,200	336,525
Important	2,400,000	384,000
Advisable	4,530,000	752,500
Total	11,187,700	1,754,340

The St. Francis levee board of Arkansas will undertake during the fiscal year 1903–4 to construct the work indicated as "Urgent" in the above table, amounting to approximately 2,000,000 cubic yards, at a cost, approximately, of $300,000, and in addition will do as much of the work indicated as "Necessary" as available funds may allow. It is thought at this time that probably as much as $150,000 additional can be devoted to this purpose.

The tables show that altogether there is yet required 11,187,700 cubic yards to complete the levee system of the Lower St. Francis district in Arkansas, which is estimated to cost $1,754,340. The contents of the levee in the Lower St. Francis levee district in Missouri and Arkansas in 1902 amounted to 13,997,681 cubic yards, and at that time it was estimated that 10,500,000 cubic yards would complete the system to the established provisional grade of the Mississippi River Commission.

It is understood that your Commission, out of available funds, will expend the sum of about $125,000 in levee construction in Missouri and Arkansas. Bids have been received for this work in localities where it is very necessary to enlarge and strengthen the levee.

In addition to the work already proposed for this fiscal year to be done by the Commission, you will be asked, through Captain Lucas, Corps of Engineers, U. S. Army, to enlarge and strengthen the levee where it is urgently needed in the vicinity of Luxora, Ark., at a cost of about $50,000.

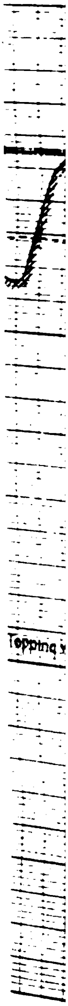
The St. Francis levee district of Arkansas has an outstanding bonded indebtedness of $750,000, and outstanding certificates of indebtedness in addition to this amount, of about $150,000. The annual interest charges on the present debt of the district amount to $53,824.20.

The last general assembly of the State of Arkansas authorized an increase of 50 per cent in the taxes for levee purposes, which will allow the collection of 6 cents per acre within the levee district, from which an annual revenue will be derived of about $105,000. The general assembly also authorized the levee board to issue an additional $500,000 in bonds. With this fund the $150,000 in outstanding certificates will be taken up, and the balance of $350,000 will be expended in constructing levee as previously mentioned.

If the levees of the Lower St. Francis levee district are to be expected to restrain an overflow of more than 50 feet on the Cairo gauge or 39 feet on the Memphis gauge, very considerable work and expenditure for raising the entire levee system is necessary.

As shown by the preceding tables, it will require the expenditure of approximately $1,750,000 in Arkansas, and probably as much as $250,000 in Missouri. This is a greater sum, it seems, than will be available from all sources in the near future, and the St. Francis levee board of Arkansas recently, in annual session, considered the advisability of presenting the condition and needs of the levee and levee district to the next session of Congress, in order to see if it will not be to the best interests of all concerned that a special appropriation of a considerable amount be made at as early a date as possible for levee construction in this district, so that a proper and economical degree of safety against overflow may be secured to the extensive and valuable interests of the levee district. This may be presented to the next Congress.

The St. Francis levee district of Missouri has done considerable work during the past year in the way of maintaining its levee, 47 miles in length, from the highlands just below New Madrid to the Arkansas State line, and has secured all necessary right of way, and materially advanced the interests of the levee district and the organization. The late general assembly of Missouri established very definitely the boundary line of the district, for purposes of taxation, amended the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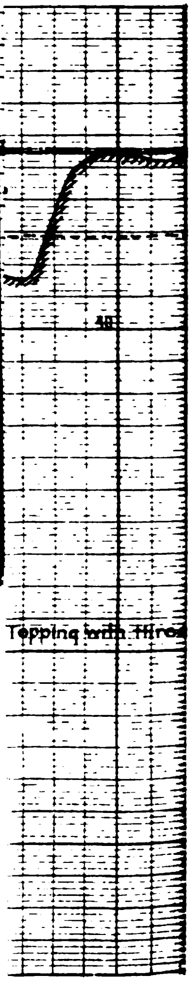
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levee law to material advantage, and authorized the levee board to issue $150,000 in bonds.

The two local levee districts in Arkansas and Missouri are thoroughly organized, and are actively engaged in the maintenance of the levee system and promotion of its best interests.

Very respectfully,

H. N. Pharr,
Chief Engineer, St. Francis Levee District of Arkansas.

Col. O. H. Ernst,
Corps of Engineers, U. S. Army,
President Mississipi River Commission.

Appendix B.

Report of C. H. West, Chief Engineer Mississippi Levee District, on High Water of 1903.

Mississippi Levee District,
Office of the Chief Engineer,
Greenville, Miss., May 14, 1903.

Sir: In response to your letter of April 6 in reference to the resolution of the Commission requesting a statement "descriptive of the high water of 1903 in this district, and the condition and needs of the levees therein," I have the honor to submit the following:

There were two crevasses in this district, both south of Greenville, one at Lagrange, 3 miles below (480 L. below Cairo), the other at Albemarle, about 90 miles below Greenville (569 L. below Cairo). Both crevasses occurred on March 27 at about the same time.

The Lagrange crevasse occurred from weakness developed at the base. The material composing the embankment and the ground over which it was built was a sandy loam. The levee itself showed no indication of weakness, but the ground immediately behind the levee was quite soft, and numerous boils appeared which discharged quantities of sand. The movement of the silt from beneath the levee soon created a cavity into which the back slope of the levee settled, when instantly the water gushed through and the entire embankment caved in. The crevasse widened rapidly, and in four or five days attained a width of 3,875 feet, after which it ceased to widen.

The water from this crevasse extended about 4 miles to the north, flooding most of the town of Greenville, and about 10 miles to the east, flooding nearly all the territory between the river and Deer Creek for a distance of about 45 miles to the south, where it met the water that had backed up the Yazoo, and below that point spread over all the lower end of the basin.

The levee at Lagrange was built in 1868, the original levee forming about one-fifth of the embankment, it having been added to several times. The last improvement was made in 1898 by the United States, at which time it was raised and enlarged to a standard section, and with a grade 3 feet above the 1897 high water, and reenforced with a banquette on the land side 8 feet below the top of the levee. At the time of the crevasse the water was nearly level with the top of the levee.

The Albemarle crevasse occurred from overtopping. This levee was built in 1898, was well constructed and of good material, but was insufficient in grade and section. It was without banquette and had a crown of only 4 feet in width and a front slope of only one on two. The water came from 1 to 2 feet higher than the top of the levee, and it had to be raised with sacks and with plank and dirt, all the dirt for this work being taken from the back slope of the levee—always a risky thing to do—but in this instance there was no way to avoid it, as the ground in the rear was covered 4 or 5 feet deep by backwater from around the lower end of the system. The immediate cause of this crevasse was the washing out of place of part of the narrow topping work by waves from a passing steamer, and the stream once started cut the levee through before anything could be done to check it. This crevasse attained a width of 1,100 feet. The water from it overflowed very little territory not already inundated by backwater from around the lower end of the system.

The total area flooded in the Yazoo Basin this year is estimated at 1,460 square miles, including about 100 square miles in the extreme lower end of the basin and below the end of the levee system. Six hundred and fifty square miles were inundated by water backing up the Yazoo around the lower end of the levee system before the crevasses occurred, and about 810 square miles additional were inundated by the crevasse water. Of the total area flooded, about 500 square miles were in cultivation and the balance in timber.

Except in the immediate vicinity of the Lagrange crevasse, comparatively little damage was done by the overflow, as the water receded from the greater part of the country flooded in time for the people to plant their crops. After the river had fallen sufficiently to make it practicable to undertake it, a protection work was built around the front of the Lagrange crevasse, so as to stop the inflow and free the country behind from the overflow in time to begin planting operations. This protection work was begun on April 20, and by April 30 practically all the inflow was stopped. The cost of the work was about $19,200, which expenditure was justified, as it allowed the people to plant in time to insure their raising a crop.

At the time the work was begun the river had fallen 9.5 feet from its highest, and there was an indication of another slight rise. The river remained practically stationary during the progress of the work and all conditions were favorable.

The line of the protection work was 7,200 feet long; 4,100 feet of the line was on ground showing above the water and over which a small levee was built in the ordinary way; 3,100 feet of the line was in water from 1 to 3 feet deep, except for a distance of 125 feet, where the water was from 15 to 18 feet deep, with a strong current.

Through the shallow water light pile cribbing with a plank and sack dam was built. Through the deep water three lines of large piles were driven with a steam pile driver; the piles were strongly braced with wire cable and timber braces. A brush mat was placed under and a mat or screen in front of the piles, after which a sack dam was built in front to cut off the inflow. Every assistance was rendered by Mr. Arthur Hider, United States assistant engineer, acting for Captain Potter, in furnishing the necessary plant, such as steamboats, quarter boats, matboats, barges, and pile driver.

The present standard of levee section has proven to be sufficient for a levee not exceeding 15 feet in height, if properly constructed of good material and over a good foundation, but the higher levees should have wider banquettes. If, for instance, a levee 15 feet high should have a banquette 20 feet wide, then for a levee 20 feet high the banquette should be 30 feet wide, and for a levee 30 feet high the banquette should be 40 feet wide; that is, the width of the banquette should be approximately proportional to the height of the levee. The upper slope of the banquette should be one on five.

Where the material composing the levee and the ground over which it is built is of a poor class, such as light or sandy loam, the section should be flattened on the land side to a slope of one on four above the banquette and one on five below. Where the levee crosses bayous or sloughs these should be filled for some distance from the base. In localities where sand boils appear the berm should be raised so as to force them to find a vent at a distance from the base which will insure that the material discharged does not come from under the levee. Where the levee is much exposed to wave wash the river-side slope should be at least one on four.

Great care should be taken in regard to the excavations of pits, both as to the depth and distance from the levee, and when practicable there should be a thorough system of drainage along the land side of the levee. In crossing old lake beds the pits on the land side should not approach nearer the levee than 200 feet, and in some localities pits on the land side should be avoided altogether.

The present allowance of 10 per cent additional height to cover the shrinkage for work done by teams is not sufficient for all classes of material, and it should be increased to 15 per cent. Another factor that makes it difficult to maintain the grade of the levee is the settlement of the foundation. This occurs in some degree in the case of nearly all levees as much as 18 feet or more in height, and is sometimes very considerable, as in the case of the levee at Stops, built in 1898, across an old lake bed, in which instance the vertical settlement at one place was as much as 50 feet. While these settling levees may give trouble to maintain the grade for a few years, they seldom give trouble at the base, as the material underneath becomes so compact that it allows very little seepage through it.

In localities where the surface stratum is a poor class of material a very large muck ditch should be cut through it, and this refilled with the best material obtainable, which should be puddled or tamped in thin layers while being filled.

The danger to which the levee in some localities is subjected from the erosive effect of the current was apparently greater this year than formerly, owing to the higher stage and greater velocity of the current. Spurs that have been built to deflect the current were in some instances undermined and washed away almost to the levee. Prominent angles in such localities should be avoided, and gentle curves substituted so as to allow the free flow of the water.

Experience teaches that too close attention can not be given to the details, or what may be termed the refinements of construction and maintenance. With some slight modifications the present specifications contain about all the essential requirements for the building of safe levees.

Special attention was given to obtaining an accurate record during the high water this year of all data that might be of future value. The height reached by the water was recorded at short invervals along the levee, and at every place where weakness of any kind developed in the levee, the locality and nature of the same were noted with a view to permanently treating the defects. While the high-water slope is quite uniform along the thread of the channel over long reaches of the river, this is by no means the case along the levee, and as it is the height of the water along the levee that must determine the grade of the embankment, it is very important to record this plane at frequent intervals. The flow of the water along the levee line meets with obstructions and local influences which cause the slope to be quite steep in places and nearly flat in others. A change in the position of a levee may cause a very pronounced local change on the flood plane. This is well illustrated by the building of the Huntington Short Line levee across the point opposite Arkansas City. The water came against this levee for the first time this year, and the flow of so large a volume by this short route and meeting with the water on the lower side caused it to bank up along the lower portion of the new levee and for some distance below. At the lower side of the point the water was 4.3 feet above that of 1897.

The effect of the flow across the point was to lower the flood plane just above in Choctaw Bend, where it was only 0.5 foot above that of 1897.

The river at Arkansas City, situated in the bend opposite, being relieved of the water which flowed across the point, did not reach as high a stage there as it would have done had the controlling levee remained as it was in 1897. The normal difference at flood between the Arkansas City and the Greenville gauges has heretofore been about 5 feet. In 1897 Arkansas City was 51.9 feet and Greenville 46.7 feet, a difference of 5.2 feet. In 1898 the stages were 51.1 and 46.2 respectively, a difference of 4.9 feet. This year the gauge at Arkansas City was 53 feet and at Greenville 49.1 feet, a difference of only 3.9 feet, or about 1 foot less than heretofore.

The water this year was higher at all points along the district than in 1897. Above Arkansas City it was an average of 1.3 feet higher, and below there an average of 2.5 feet higher. In some localities below Greenville it was 3 feet and over above the 1897 water. The greatest difference was in the bend above Shiloh, where at one place this year's water was 4.5 feet above that of 1897. It is interesting to note that at this place (554 L.) the water was 1.2 feet higher in 1898 than in 1897.

The grade to which the levees in this district have been constructed is 3 feet above the 1897 high water, but in many places the settlement of the embankments have been more than was anticipated and they were below that grade, and about 20 miles of the line in the lower end of the district had not been raised to the provisional grade of 3 feet above the 1897 high water; and on all of this stretch, as well as in many other localities, considerable work was required to keep this year's water from overtopping the levee.

The following table gives the highest stages in 1897, 1898, and 1903 on the gauges covering the front of this district, and a comparison of the heights of 1903 with those of 1897 and 1898.

Station.	1897.	1898.	1903.	1903 compared with—	
				1897	1898.
Sunflower Landing	47.2	46.0	48.0	+0.8	+2.0
White River	52.4	51.5	53.7	+1.8	+2.2
Arkansas City	51.9	51.1	53.0	+1.1	+1.9
Greenville	46.7	46.2	49.1	+2.4	+2.9
Lake Providence	44.5	44.4	46.5	+2.0	+2.1
Vicksburg	52.3	49.4	51.8	− .5	+2.4

The comparison of the gauge readings of 1903 with those of the other two years shows the water this year to have been much nearer parallel with that of 1898 than of 1897.

In 1897 there were five crevasses in this district, three of which occurred about Arkansas City and considerably in advance of the crest of the rise, the effect being to cause relatively lower gauge heights south of Arkansas City than above there.

In 1898 there were no breaks in the levee line in this district or on the opposite side of the river south of the Arkansas. The breaks that occurred this year, being toward the lower end of the system and very near the crest of the rise, had very little effect on the gauge readings. Just prior to the break at Lagrange it was rising at Greenville at the rate of a little more than one-tenth of a foot in twenty-four hours and, taking 1898 as a guide, it would have continued to rise for about four days longer, so that it is probable that if the Lagrange crevasse had not occurred the stage would have been three-tenths of a foot higher, or 49.4 feet. A little less would have been added to the gauge readings at Arkansas City and a little more at Lake Providence and probably at Vicksburg.

There seems to be but little doubt that the high water of this year affords a better basis upon which to fix the grade of the levee in this district than does that of 1897. Allowances, of course, should be made for the raising of the flood plane in the upper end of the district in case the White River Basin is securely closed, and for the slightly higher stage it would have reached below if the crevasses had not occurred this year.

The highest stage at Cairo in 1897 was 51.7 feet, and the duration of over a 50-foot stage was from March 18 to April 5, or eighteen days. This year the highest stage at Cairo was 50.6 feet and the duration of over a 50-foot stage was from March 13 to March 20, or seven days. Thus, with a 1.1-foot lower gauge reading and eleven days less duration of over a 50-foot stage at Cairo, there was a 2.4-foot greater stage at Greenville, so it is safe to assume that with complete confinement a flood like that of 1897 would go 1.5 feet higher at Greenville than it did this year, or at least to 51 feet or over.

Without speculating further as to the ultimate flood heights that may be expected and looking to what is best to be done in the immediate future, I think it advisable to first bring all the levee line in the district up to some uniform but moderate height above this year's water before beginning to build any part of it up to the estimated ultimate grade. I would suggest a provisional grade of 2 or 2.5 feet above this year's water and, as it is important to accomplish this at the earliest possible date, it may be well to adopt the lower grade suggested. With the levee uniformly 2 feet above this year's water we could reasonably expect to confine a flood such as this was, or even a greater flood, and then the data would be at hand for estimating with a considerable degree of certainty what the ultimate grade and section of the levee should be for confining the highest waters that may be expected.

Very respectfully,

C. H. West,
Chief Engineer, Mississippi Levee District.

Col. O. H. Ernst,
Corps of Engineers, U. S. Army,
President Mississippi River Commission.

APPENDIX C.

REPORT OF T. G. DABNEY, CHIEF ENGINEER YAZOO-MISSISSIPPI DELTA, LEVEE DISTRICT, ON HIGH WATER OF 1903.

Clarksdale, Miss., *May 22, 1903.*

Dear Sir: I regret that circumstances rendered impossible an earlier compliance with your request of April 6 for "a statement descriptive of the high water of 1903," etc., along the front of this levee district.

I can now only give you some excerpts from my report to the levee board, as follows:

The subject of the recent high water will first be considered, with the lessons to be learned from it and the consequences to ensue.

In comparing the flood of 1897 with that of 1903, it is apparent that the former was of much greater magnitude than the latter—that is to say, the volume of water that passed Cairo in 1903 was much less than that of 1897. This may be illustrated by pointing to the fact that in 1897 the river at Cairo remained above the 48-foot stage forty days, while in 1903 that period was only 18 days. The 50-foot stage was exceeded in 1897 for eighteen days, the corresponding period in

1903 being eight days only; and the maximum gauge reading in 1897 was 51.6 feet, while in 1903 it was 50.6 feet, or one foot lower.

Under the above state of facts as to Cairo, the maximum stage at Memphis this year exceeded that of 1897 by exactly 3 feet, and this excess was prevented from reaching a still higher point by the two large crevasses that occurred in the St. Francis levee two or three days before the culmination of the flood at Memphis. The additional flood elevation that would have been reached at Memphis had those crevasses not occurred is, of course, matter of conjecture to a considerable extent, but it seems probable that about half a foot would have been added to the gauge reading. Assuming this to be true, and adding another foot for the difference at Cairo between the former and the present year's flood elevation, the result will be not much below 42 feet for the Memphis gauge, with a flood volume equal to that of 1897; and, with allowance for a longer continuance of the high water and a still higher stage at Cairo, that figure may be reached or perhaps somewhat exceeded as the ultimate maximum gauge reading at Memphis.

It is a matter for regret from an educational standpoint alone that the breaks in the Arkansas levee occurred before the flood culminated at Memphis.

At Helena the highest gauge reading was 51 feet, exceeding the Cairo maximum by four-tenths of a foot and falling under the 1897 record eight-tenths of a foot. The Helena record was again vitiated for educational purposes by the escape of flood water into the St. Francis Basin, as has occurred in all former flood years, but that influence had much less effect this year than in any former high-water year, with perhaps 1898 excepted.

The excessive flood height at Memphis was not unexpected, though it somewhat exceeded my anticipations for the volume of water that passed Cairo.

It may be remarked that the relations between the Memphis gauge on the one hand and those at Cairo and Helena were rather consistent, Memphis falling 10.5 feet below Cairo and 10.9 feet below Helena. The difference as to Cairo would have been diminished by about half a foot had not the St. Francis crevasses occurred, from which it may be inferred that the ultimate relations between the Cairo and Memphis gauges when the entire flood volume shall be confined to the channel should be about same—that is to say, that the Memphis maximum should continue to be about 10 feet below the Cairo maximum.

The same cause that modified the Memphis maximum this year also modified the Helena maximum, so that no safe deduction can be made from this data as regards the ultimate relations of these two gauges.

DETAILS OF THE FLOOD.

I will now show in some detail the elevations of this year's flood plane along the front of this levee district as compared with that of 1897.

The excess head of water at Memphis this year was projected downstream, being prevented from escaping into the Lower St. Francis Basin by an extension of the line of levee on that front to a point about opposite Norfolks Landing on our side. From the terminal of that line no continuous levee exists until a point about opposite Commerce is reached, where a detached line of levee begins and extends down to a point opposite section 36 of our line, about 1¼ miles below Mhoons Landing. From this point to the mouth of the St. Francis River, a distance of 16 miles by river, no continuous levee exists.

Under the partial restraint afforded by these St. Francis levees, upon the escape of the flood water from the main river, the flood elevation at Lakeview was 2.8 feet above that of 1897. This plus elevation was practically maintained along our levee for the first 6 miles, while at Norfolk, on section 10, it diminished to plus 2.2 feet.

From Norfolk to Commerce, section 25, there is a gradual diminution to plus 1.3 feet at the latter point, which super-elevation is neutralized 6 miles below by a practical coincidence of the two flood planes on section 31, and at Mr. Walter Johnson's, section 32.

Below here is another slight divergence showing a plus elevation of four-tenths of a foot at Mhoons Landing, section 34, the two planes crossing on section 36.

Below the latter point the divergence is in the other direction, showing minus elevations for the 1903 high water, as compared with 1897. This divergence is quite rapid from its initial point, the minus elevations being 1.2 feet at the Saunders place, section 38, with 1.4 feet at McKinney Bayou, section 40, and 1.1 at Austin, section 43. Below Austin the divergence is reduced to a minus of eight-tenths of a foot on section 46, which is maintained about uniformly to a point opposite Helena, about 10 miles below.

From Helena southward the White River Basin front has an unbroken line of levee 29 miles long, extending to a point opposite section 85, a mile below Burks Landing. Below this terminal, within the next few miles are four unclosed crevasses that occurred in 1897, aggregating over a mile in width.

The effect of this 29 miles of unbroken levee along the upper White River Basin is shown on the flood plane, in which the minus elevation for this year of eight-tenths at Helena is reduced to nothing at Delta (or mile post 65–66), from which point the two planes are practically coincident to a point 3 miles below Friars Point, sections 72–73, showing a relative elevation along this 7 miles, eight-tenths of a foot above Helena.

From section 73 southward this year's flood plane falls a little below that of 1897 down to the vicinity of Burks Landing, where it was a few tenths above, was coincident at the Ward Lake junction, and nearly a foot above at Rescue Landing, the latter probably due to a local depression in 1897 at the last-named point caused by a crevasse nearly opposite on the Arkansas side.

WARD LAKE AND HUSHPUCKANA SYSTEMS.

The back-water plane at the western junction of the Ward Lake line was this year seven-tenths of a foot higher than in 1897, in conformity with the higher elevation at Rescue, while the two front water planes on the opposite side of the levee were here coincident, the difference between the front and back waters being here 4.75 feet this year as against 5.35 feet in 1897. The back-water plane along the Ward Lake line to the eastern junction and southward along the Hushpuckana system for 5 miles showed a slope of three-tenths of a foot, while no slope was observed in 1897. Also it was noted that the current against the Greengrove front showed between half a mile and a mile higher up than formerly.

At milepost 13–14 (H.) on the Greengrove front this year showed a plus elevation of four-tenths of a foot, with five-tenths at Sunflower store, which gradually diminished to nothing at milepost 19–20 (H.), half a mile above Malone's store. At the latter point this year's water fell a few tenths below 1897, which minus was increased to half a foot a half mile farther down. The two planes again crossed about Lake Charles Landing, the present year rising above 1897 half a foot at Pushmataha, and eight-tenths of a foot between there and the Bolivar County line, at which latter point the plus elevation was a little more than half a foot.

The various oscillations of the two high-water planes south of Helena were due to the varying conditions of the White River Basin levee as between this year and 1897, with perhaps the relative flood conditions of the White River as a factor also.

GRADE LINES.

As regards deductions to be made from the high-water data of this year with reference to grade lines, it may be said that the estimate heretofore made of the ultimate high-water elevations at Lakeview, upon which the grade of that part of the levee is based, was a little under 5 feet above the 1897 flood plane there, and it now seems probable that 5.5 feet above 1897 would have been nearer correct.

Going on farther down the levee, there has been no change in preexisting data of sufficient decisiveness to warrant any present change in former conclusions.

HIGH-WATER ORGANIZATION.

As the high water approached an organization was formed for meeting the danger in the most effective manner. For this purpose the entire levee front was cut up into nine divisions, over each of which was placed a discreet and reliable resident planter as master of division, one of whom, Mr. E. K. Holloway, is also a member of the levee board. With the exception of Mr. Holloway, the gentlemen selected for these positions were all men of experience in combatting high-water dangers, in which category Mr. Holloway also may now be reckoned.

The duties assumed by the masters of divisions in accepting these charges were:

(1) To keep me advised at all times of the levee situation on their respective divisions by telephone, and to confer with me regarding the measures to be used in combatting particular dangers as such should develop.

(2) To use their discretion in placing guards on the levee, and in calling out plantation hands to work on the levee, and in selecting foremen over the hands.

(3) To make requisitions on this office for materials, tools, etc., and for money to pay the hands and guards.

(4) In emergencies to take prompt steps in their own discretion to meet immediate dangers.

ENGINEERING STAFF.

The above was the citizen organization, which was supplemented by the engineering staff, as follows:

Mr. W. R. Wallis, resident engineer, with Rodman R. L. Barry, had general charge of the line above Austin.

Mr. P. E. Regan, first rodman, had local charge at and below Austin.

Mr. J. R. Engle, resident engineer, had active charge on the Burk front, Rescue, and Ward Lake.

Mr. M. Gardner, United States assistant engineer, had charge at Malones Landing and vicinity.

Mr. A. L. Dabney, Acting Assistant Chief Engineer, had general charge of the whole line, stationing himself at different times wherever the most critical situation appeared to exist.

The chief engineer remained at headquarters throughout the entire high-water period and was in momentary touch through the telephone with every part of the line both day and night, and was at all times kept fully informed of all developments as they occurred. In this very trying position he was efficiently and faithfully assisted by Mr. W. L. Head, office engineer.

I will here add that I consider the above general system of high-water organization as an ideal one, and that it worked admirably in its practical application.

LESSONS OF THE FLOOD.

The following deductions are drawn from the experience of 1903 high water:

(1) The levee proper—that is, the body of the structure—showed no weakness, with trifling exceptions, but proved amply strong to withstand the pressure with the standard cross section and banquette reenforcement.

(2) The 40-foot width of banquette proved of inestimable value, as affording material from its outer half to top some 10 miles of low-grade levee, where dirt could not not otherwise have been obtained except under great difficulties.

(3) The most vulnerable feature of the levee system is the instability of the foundation along much of the line, which evil is greatly aggravated by the existence of excavations for barrow pits on the land side of the levee.

The passage of water in large volumes through permeable strata under the base of the levee constituted the most formidable danger to be combatted, requiring the most attention and effort. This evil has, of course, been much in evidence in former high waters, and wherever such development has occurred a permanent remedy was applied by building sublevees behind the main levee, so as to impound water over the area of the defection of sufficient depth to control the situation. In one such basin of unusual extent (over 3,000 feet long by 400 feet wide), an 8-inch siphon over the main levee is used to hasten the filling of the pond.

The sublevees are provided with spillways of plank over the top and iron drain pipes with gate valves underneath. The sublevee device has been used in this levee district for a dozen years past and has in every case proven a perfectly efficient remedy.

The development of foundation weakness in many new localities this year will require a corresponding extension of the sublevee principle, and with increased river stages that may be expected in the future, the necessity for making adequate provision to meet this source of danger will become still more pronounced.

(4) Two other difficult problems that were especially emphasized during the recent high water, and for which no very satisfactory solution has been found, remain to be considered. The one is the protection of exposed salients in the levee line from erosive action of the current; the other the protection of the levee from wave wash where it is much exposed to storms.

Taking up first the exposed salients, these are points where a decided change occurs in the direction of the flow of the flood water along the levee line, accentuated by a steepened slope due to short cuts across bends of the river.

The degree of the menace to the levee depends upon the comparative abruptness of the turn, combined with the degree of steepness of the slope.

In the severer cases the attack takes the form of vertical scour, tending to undermine the levee, as well as lateral erosion, tending to wash away the front slope.

In the milder cases lateral erosion alone has to be reckoned with, or if there is vertical erosion also, it is not difficult to control.

In this levee district are seven such exposed salients, including one that is not an angle, but is the "loose end" of the front line on section 91, below Rescue Landing, which, to use a military term, is "in the air."

The "front line" projects nearly 4 miles below the "Ward Lake line," a cross levee connecting the front and back systems, and terminates abruptly on the upper side of the bend in the river, on the lower side of which bend is Sunflower Landing.

The method of protection used for these exposed points is to project a "spur" levee 200 to 300 feet long from the salient angle of the levee out into the current, protecting the head of the spur by a plank bulkhead, with plank or brush revetment on the ground surface, and permeable brush dikes to moderate the violence of the current around the bulkhead.

During the recent high water no serious difficulty was encountered in maintaining these spurs, except in the case of that one on section 36 (about 2 miles below Mhoons Landing) and the levee end below Rescue, section 91.

The current around the 36 spur was exceedingly violent, the fall there being nearly 4 feet from 1 mile above to 1 mile below, with an abrupt descent of nearly 1½ feet immediately around the spur end. The vertical scour was more than 20 feet around the bulkhead, most of which was carried away. The spur was held with difficulty and gave occasion for considerable anxiety.

It is now proposed to cut off about half the spur, reducing the length to 150 feet in order to afford more room for the passage of the water around it, and as a matter of additional security to construct a reserve line of levee behind the salient, in a regular curve, tangent to the levee line above and below; this reserve levee to be 1,100 feet long, the center of the curve being retired 300 feet behind the salient in the main line.

On the levee end on section 91, a very elaborate and carefully constructed protection work was carried away completely in a few hours, some days before the flood culminated. The levee end receded 260 feet in despite of energetic and persistent efforts to restrain it, the ground being scoured away to a depth of 10 feet below the base of the levee throughout that distance.

The signal failure to protect this levee end from the violence of the current in that locality, in connection with certain bank caving complications also, has induced me to recommend to the levee board that further efforts to maintain this projecting levee end be abandoned.

This will involve a radical change in that part of our system of levee protection, as the projecting levee end below the Ward Lake line incloses a "back water" basin, and controls the high-water elevation in same, to which the present grade of 10 miles of levee is adjusted.

It will remain, therefore, either to build up the Ward Lake line to the head-water grade, or to build an interior line farther up to connect the front and back systems, and throw out the front line below the point of divergence as well as the Ward Lake line. There are many reasons which will not be here presented for favoring the latter course.

WAVE WASH.

A very violent wind storm occurred after the flood had subsided between 1 and 2 feet that created much alarm for the safety of the levee on the Friars Point front, and the Pushmataha front, and other localities, and required very energetic work for ten or twelve hours to resist the action of the waves, notwithstanding which inroads were made into the middle of the crown of the levee in places before the wind subsided.

The inefficiency of the log booms in such a violent storm, upon which reliance had been placed, was fully demonstrated. It is necessary to devise some more effective appliance to protect exposed portions of the levee from wave action, which has not yet been determined upon.

REQUIREMENTS OF THIS LEVEE DISTRICT FOR CONSTRUCTION DURING THE PRESENT YEAR.

For new levee covering the Star Landing front, sections 13 to 15, about 2 miles long, approximately	$50,000
For new levee from Indian Creek to Commerce, about 2 miles long, sections 23 to 25, approximately	50,000
For enlargement of old levee from Commerce southward, part of section 25 to section 29, inclusive, about 4½ miles, approximately	35,000
For supplementing United States contract on sections 43 to 50	10,000
For enlarging levee on Friars Point front	14,000
New levee connecting front line with back line, from lower end of section 81 to lower end of section 8 of the back line, a little over 3 miles long (for two years, $311,000; one-half this year)	155,000

For enlarging back line from Ward Lake line southward to live water, sections 9 to half of 14, inclusive, to headwater grade ($145,000 in two or more years) this year	$25,000
For enlarging Hushpuckana Crossing and for sublevee across channel	7,500
For enlarging part of sections 17, 21, and 22 of back line	14,000
For enlarging sections 23 and 24, Pushmataha front	10,000
For banquette behind new United States levee at Malones Landing	30,000
Total for this year	400,500

The above does not provide for sundry sublevees about the cost of which no specific information has yet been obtained.

I will send by this mail a high-water profile, showing the relations of the 1897 and 1903 flood planes along the front of this levee district.

Very respectfully,
T. G. Dabney,
Chief Engineer, Yazoo-Mississippi Delta Levee District.

Col. O. H. Ernst,
Corps of Engineers, U. S. Army,
President Mississippi River Commission.

APPENDIX D.

REPORT OF H. B. RICHARDSON, CHIEF ENGINEER STATE BOARD OF LOUISIANA, ON HIGH WATER OF 1903.

New Orleans, La., *May 19, 1903.*

Gentlemen: In compliance with the request contained in your resolution transmitted in a letter from the president of the Commission of date April 6, 1903, I have the honor to submit the following statement relative to the "High water of 1903, and the condition and needs of the levees" on the Mississippi River protecting the alluvial lands of the State of Louisiana.

INTRODUCTORY STATEMENT.

The levee system directly protecting the State of Louisiana against overflow from the Mississippi River extends on the right bank from "Costello's Gin" on Amos Bayou, Desha County, Ark., to Bougere Landing, about 26 miles above the mouth of Old River—usually known as the mouth of Red River—a distance by river of, say, 333 miles, and from Barbres Landing on Old River, at the head of the Atchafalaya, to the Jump, 10 miles above the Head of the Passes, a distance by river of about 302 miles.

At Donaldsonville, 182 miles below the so-called mouth of Red River, this line is interrupted by the outlet of Bayou Lafourche, which is leveed on both sides for some 80 miles below. On the left bank the levee system extends from Baton Rouge to Bayou Goubray, below Fort St. Philip, a distance by river of about 207 miles.

Between 1886 and 1902 the State legislature has created fifteen levee districts, each having a board of commissioners invested with corporate powers to provide and administer revenues for the construction and maintenance of levees. The line above referred to comprises the levees along the Mississippi River in eight of these districts, viz, on the right bank: In the Fifth Louisiana levee district, from the Arkansas line to near the mouth of Red River, about 218 miles; in the Atchafalaya Basin levee district, from Barbres Landing on Old River to the head of Bayou Lafourche at Donaldsonville, about 128 miles; in the Lafourche Basin levee district—except the city of New Orleans—from the head of Bayou Lafourche to Riceland, about 120 miles; and in the Buras levee district, from Riceland to the Jump, about 34 miles. The Tensas Basin levee district, lying in the interior between Bayou Maçon and the Ouachita River, aids in the construction and maintenance of levees on the right bank of the Mississippi River in Desha and Chicot counties, Ark. On the left bank: The Pontchartrain levee district has a levee line extending from Baton Rouge to New Orleans, about 126 miles; the Lake Borgne levee district, a line from New Orleans to Bohemia, about 48 miles; and the Grand Prairie levee district, a line from Bohemia to Fort St. Philip, about 26 miles; while the Orleans levee district has levees on both banks of the Mississippi coterminous with the limits of the city of New Orleans, about 13 miles on each side.

The levee systems of these districts, with the 85 miles of levee in Arkansas upon which Louisiana is directly dependent, have an aggregate length on the Mississippi River of about 811 miles; while the levees on interior streams—the lower Red, the Atchafalaya, the Des Glaizes, and the Lafourche—which are more or less brought into service by flood stages of the Mississippi, sum up a length of over 260 miles, thus making the total length of levee line directly protecting Louisiana against overflow from the Mississippi River and subjected to strain by the high water of 1903 exceed 1,070 miles.

HIGH WATER OF 1903.

The high water of 1903 as affecting the levees of Louisiana may be said to have begun in December, 1902, although the stages reached at that time in the Mississippi River did no harm except to interrupt some of the work of levee enlargement then in progress. On Red River, in the northern part of the State, the water was at some points higher than ever before recorded. One crevasse occurred about 50 miles above Shreveport, while the enormous erosion of the river banks—in some places on both sides at the same time—made a vast amount of work necessary on hastily built loops around the places breached or threatened by the rapid caving.

But the December floods had generally declined by the end of January, and it was not until the heavy rains which occurred throughout the valleys of the tributaries in the first two weeks of February that the probability of a dangerous high water in the Mississippi became apparent. After about the 5th of February the rivers in Louisiana rose continuously and a part of the time rapidly, so that within the next two weeks the water was generally well against the levees in all parts of the State. On the lower Mississippi, at Fort Jackson, the gauge read the same as the highest in 1897 (7.2 feet) as early as March 5, and by March 21 it reached 8 feet, that is, eight-tenths of a foot higher than any stage previously recorded. Near the upper end of the State—at Lake Providence—the high-water mark of 1897 (44.54 feet on the gauge) was passed this year on March 19, and on March 27 the gauge reading was 46.45 feet, or 1.9 feet higher than the highest of previous record.

At Vicksburg, 57 miles below Lake Providence, the highest stage this year was seven-tenths of a foot below the highest of 1897; while from St. Joseph to Natchez the water was from two-tenths to six-tenths of a foot higher than in 1897. From Red River Landing to College Point, the highest stage of 1903 was from two-tenths to six-tenths foot lower than the highest of 1897; but at New Orleans and at Fort Jackson it was about eight-tenths of a foot higher than in 1897, and at intermediate points higher still.

The lower part of the river reached proportionately high stages this year sooner than similar stages were reached above. For instance, at Fort Jackson a half stage appeared four days earlier than at Baton Rouge, 206 miles above; a three-quarter stage nine days earlier, and the highest seventeen days earlier. The flood of 1897 also exhibited the same sort of prematurity in its stages below, though in the floods of 1898, 1899, and 1900, such marked advance of dates was not apparent.

The floods of 1897 and 1903 were both preceded by three or four years of only moderate high water.

These facts may further corroborate the conclusions relative to the increased carrying capacity of the river between Carrollton and Red River Landing, stated in the paper by Major Derby, published as Appendix I of your annual report of 1900. They may also indicate that the maintenance of such increased capacity is, as might be expected, dependent upon the passage of the larger floods, and that even the largest floods require time for the accomplishment of their work.

The effect of crevasses in limiting flood heights in Lousiana this year appears to have been insignificant. The crest of the flood wave coming down the river must have nearly reached the upper line of the State when the breaks in levees on the opposite side below Greenville occurred. A further rise of three or four tenths of a foot, or, say, to 47 feet on the gauge, was the most that could have been expected at Lake Providence. The largest crevasse of the season, at Hollybrook, 5 miles below, occurred when the river had already fallen over 2 feet at Lake Providence, and a foot and a quarter at Vicksburg. It, of course, had no influence upon the maximum stage in that locality. While the return to the river of flood water from these crevasses at Vicksburg and the mouth of Red River evidently prolonged the high stages at those points, it apparently failed to produce an increase of height at either place.

The only other important crevasse on the Mississippi River in Louisiana, at

Hymelia, 36 miles above New Orleans, was so constantly worked upon in the efforts made for its closure that its discharge was never sufficient to appreciably affect the flood stage, which had practically culminated at the time the break occurred.

The water in Bayou Lafourche, as usual, rose to excessive heights. At some points from 30 to 50 miles below its head the stage was at least a foot higher than in 1897. Three breaks occurred in the levees on its right bank. In the Atchafalaya, at Melville, about 30 miles below its head, the stage was 2.6 feet higher than in 1897. This extreme high water in both these streams—and also to a large extent that in Bayou Des Glaizes and the lower Red—was, of course, due to the high stage of the Mississippi.

CONDITION OF THE LEVEES.

The continued work on the levees of Louisiana during the past twenty years by the levee districts, the State, and the United States has resulted in a constant improvement of their height, width, and location, so that the flood of 1903 found them better in grade, section, and apparent strength than they ever were before. At the same time there remained in most of the districts many stretches of levee with little or no margin of height above the flood level of 1897, and with corresponding deficiency in width and mass. In the Pontchartrain levee district alone it was estimated that as much as 21 miles, or one-sixth of its levee line, stood less than 1 foot above the high water of 1897, while in other districts, although the proportion of low levees was nowhere as great, there was some 12 miles more, making an aggregate of, say, 33 miles.

When it became evident that the rivers in Louisiana might rise to a height equal to or above the high-water mark of 1897, the levee commissioners of the several districts and your executive officers began the work of raising the crowns of the lowest levees. This was generally done with a small bank of earth revetted on the water side with one or two lines of inch plank, or sometimes with several tiers of earth-filled sacks.

The total length of this class of work on the Mississippi River in Louisiana was about 71 miles, some 24 miles of which proved actually necessary to prevent water running over the tops of the levees, and a much greater length to prevent waves washing through them where the margin above water was only a few inches.

In the upper part of the State the commissioners of the Fifth Louisiana levee district found it necessary, on account of the unprecedentedly high stage of the river, to raise the levee south of the Arkansas line from 1 to 2 feet for a distance of 17 miles; and the rise of the river was so rapid that there was not time to obtain earth otherwise than by cutting away a part of the crown and taking a slice from the upper portion of the rear slope of the levee. The water stood against this emergency work, overtopping the crown of the original levee in some places as much as 2 feet. In the lower part of the State also—especially in the Buras and Grand Prairie districts—the water overtopped the levees for a length aggregating at least 5 miles; and although the levees there were raised for a much greater length, it was found impossible in the Grand Prairie district to prevent this temporary work from being washed away in some places by the waves, which were mostly caused by the passing of large ocean steamers.

Inspectors, watchmen, and guards were generally placed on the levees by the commissioners in all the districts of the State, the Tensas Basin levee district sending 40 guards outside the State to Desha County, Ark.

Your executive officers stationed boats loaded with tools, sacks, lumber, etc., at convenient intervals along the river, and some of the levee districts kept trains of cars similarly laden, all of which were constantly in readiness to move promptly to any point where they were needed.

The expenses incurred in this class of work by the several levee districts of the State—not including the cost of closing and attempting to close crevasses—amount to over $185,000.

Before the water came very high against the levees special attention had been generally given to the drainage of the roads and land adjacent to the levees; and wherever drains were open and made effective the firmer, drier, and less leaky condition of the levees was in marked contrast with their condition in places where drainage was deficient. During the higher stages of the flood numerous holes (usually ascribed to crawfish) developed at and near the base of the levees, and many places on the slopes became soft and sometimes began to slough down their sides. It was noticeable that such holes and sloughs were usually at places where the drainage was least efficient or most recently made.

Holes discharging muddy water were generally treated by placing earth or driving sheet piles on the river side of the levee at or beyond the base, and usually with success. In some cases "run-arounds" of earth or walls of sacks were used to surround the outlet of the holes on the land side. Sloughing places were mostly treated in a similar manner—that is, with earth placed on the river side slope—with good results, but when so extensive as to threaten encroachment upon the crown of the levee they were often covered with brush, cinders, or other porous material and loaded down with earth in sacks, and sometimes backed up with a wooden bulkhead at the toe of the sliding mass. It is not certain, however, that the same amount of work and material applied in such cases to the river side of the levee would fail to prove equally as effective.

Several breaks occurred in the Grand Prairie levee district (about 1,018, 1,025, and 1,040 miles below Cairo), due to the water overtopping the small levees there, and despite the strenuous efforts made to build them higher as the water rose. Their aggregate width is three-fourths of a mile or more.

The caving of the bank carried away the levee at Magnolia (1,012 miles below Cairo) on April 5, when the water was near its highest stage and close to the top. The levee was about 8 feet high and the cave took in a part of the land-side base for a length of about 230 feet, so that the water at once ran over the remaining part of the levee some 2 feet deep, and later 5 or 6 feet deep. By prompt action the planters in the immediate vicinity succeeded in securely closing the crevasse within the next four days, and before serious damage was caused by overflow. The cost of the work is reported as about $7,000. At several other points crevasses were barely prevented by similar prompt attention; notably at Waterloo (876 miles below Cairo), in the Pontchartrain levee district, where a large hole under the levee suddenly developed on April 13, which was only stopped by a wall of some 12,000 sacks of earth surrounding its outlet, and a cribwork and bulkhead afterwards built on the river side.

But the two most important crevasses in Louisiana were at Hymelia (928 miles below Cairo), in the Lafourche Basin levee district, and at Hollybrook (546 miles below Cairo), in the Fifth Louisiana levee district, both of which, on account of location, height of levee, and stage of river, threatened serious inundation of the levee districts in which they occurred.

The Hymelia crevasse had its origin in a hole at the base of the levee, discovered late at night on March 26, when it was described as "about as big as a hogshead." Before anything could be done to stop it the crown of the levee fell in, and the break was rapidly enlarged. The levee was built in 1891 and enlarged in 1896. It was located on a "batture" in front of the old levee line, the remains of which still stood some 2,400 feet in the rear. There was a considerable growth of willows on the fore shore which extended 1,000 feet or more in front. It was 11 feet high and had a crown 8 feet wide, with side slopes of three to one, was well grassed and had a plank revetment in front, and is said to have been well drained. The guards who were patrolling the levee are reported to have passed the site of the break but a few hours previous, finding everything apparently sound and safe—the water about 2¼ feet below the top.

No defect was known or suspected in the construction and none had appeared in adjacent parts of the line.

Although the water against the levee was deeper than that in which it has usually been found that successful work for closing crevasses can be done, it was shallower on the willow batture in front and thus presented a more favorable opportunity for the attempt than otherwise. The remains of the old levee in the rear also to some extent reduced the probable head to be encountered. The district levee board, the railroads, and the planters therefore began work next morning with large forces and ample materials and continued vigorous efforts to close the break for over a month. The cost of the work to all parties contributing is reported as at least $130,000.

The usual method was adopted; that is, parallel lines of scantling driven as deep as practicable at sufficiently close intervals to prevent sacks of earth from washing through (commonly known as "cribbing"), which appears to be the only method that has often proved successful. Sheet piling was also used later, but the bottom scoured too rapidly whenever the opening became narrower than the gap in the levee to make complete closure feasible, although at one time the cribbing had entirely surrounded the break. The final width of the crevasse in the line of the levee was about 750 feet, its size and discharge having probably been decidedly limited by the constant work done in the endeavor to close it.

The Hollybrook crevasse also had its beginning in a small hole that appeared on the side of the levee 4 or 5 feet below the top. It was first seen early in the morning of April 8 by a colored laborer living close by, who failed to attempt stopping it, but instead ran in panic to save his property and alarm his neighbors. The circumstances as regards previous inspection, the inability of those who first reached the place to close the hole, the size it then had, with the falling in of the crown, and the rapid enlargement were almost an exact repetition of those at Hymelia. The original holes at both places appear most likely to have been made by some burrowing animals, and the only difference except as to size at the time of discovery was in position. The levee where the crevasse started was about 17 feet high with side slopes of 3 to 1, crown 8 feet wide, and a "banquette" 20 feet wide at 10 feet below the top. It was built in 1877 and enlarged in 1894 and again in 1899. It was well sodded and appeared in excellent condition. The water at the time of the break was 4 feet below the top, having fallen about 2 feet since the highest stage, five days previous. There was a wooded fore shore nearly a half mile wide in front of the levee and cultivated land in the rear. No attempt was made to close the crevasse, though a line of trees was cut down and secured around it with a view to reducing the flow. It enlarged rapidly for about ten days and finally became over 3,000 feet wide.

EXTENT OF OVERFLOW.

Exact information as to the area and limits of overflow is not readily obtainable. It is probable that there are many ridges within the general boundaries of the flooded regions which remained above water and, on the other hand, possible that some small areas of overflow lie outside them. But the following statement, based on special reconnaissance and inquiry and in part upon reports from parish assessors, is believed to be approximately correct.

The area overflowed by the small crevasses in the Grand Prairie district is mostly sea marsh and does not exceed 16 square miles, about 1,600 acres (2½ square miles) of which is adapted to rice culture, though but little, if any, of the land had been prepared for sowing. The greatest damage resulting from this overflow was to the oyster beds, which had been extensively planted and were becoming the object of a profitable and increasing industry. The two larger crevasses in Louisiana, at Hymelia and Hollybrook, caused much less overflow and injury than would generally have been predicted from comparison with some of the larger breaks in levees near the same localities in previous years; for instance, with the Davis crevasse of 1884, 12 miles below Hymelia, and the Wyly crevasse of 1893, 3 miles above Hollybrook.

The water from Hymelia crevasse mostly ran back toward Lake des Allemands, spreading out only about 2 miles wide on the immediate river front, and overflowing, say, 11,000 acres of the cultivated plantations between the lake and river. The water crossed the track of the Texas and Pacific Railway, and partially interrupted its operation for about ten days.

Lake des Allemands was raised about 3 feet above its usual level and Lakes Ouacha and Cataouatche somewhat less. The total area within the limits of overflow was about 1,320 square miles, at least 1,300 square miles of which was sea marsh, low swamp land, and normal water surface. The area of cultivated land laid under water by the Hymelia crevasse was not over 12,500 acres; say, 19.2 square miles.

The overflow from Hollybrook crevasse covered over two-thirds of the area of the two upper parishes of the Fifth Louisiana levee district; that is East Carroll and Madison. In the latter parish the overflow was confined to the western part, leaving the cultivated lands on the river front untouched. The course of the water was toward the Tensas River and Bayou Maçon, and thence down those streams and through the low wooded lands adjacent, and across them into Franklin and Catahoula parishes, passing between the high lands of Sicily Island on the west and the banks of the Tensas River on the east, and mingling in Black River some miles below the junction of the Ouachita and the Tensas, with the backwater from Red River and Bougere.

The total area of overflow directly due to the Hollybrook crevasse is estimated at 930 square miles, about 46,200 acres (say, 72 square miles) of which is cultivable land, in the Fifth Louisiana levee district.

The aggregate area of overflow due to crevasse in the levees of the Mississippi River in Louisiana is thus estimated at about 2,266 square miles, of which nearly 93 square miles, or, say, 59,300 acres, is cultivable land.

The total area of cultivated land in the seventeen parishes entirely included in the levee districts (except the Orleans district) bordering the Mississippi River was, in 1901, according to the report of the State auditor, 770,114 acres. The cultivated area has certainly been increased since that date; but leaving this out of the account, and also, because it can not be definitely stated, leaving out the area included in the four parishes, parts of which only are contained in these levee districts (which area, by the way, was not overflowed in 1903), there was less than 8 per cent of the cultivable land in these parishes overflowed by crevasses. If the actual figures were available the area overflowed would probably prove to be less than 7 per cent; that is to say that at least 92 per cent and probably a considerably larger proportion of the cultivable lands in the levee districts bordering the Mississippi River was protected against overflow from crevasses by the levee system, every acre of which must have been inundated had there been no levees.

The greatest overflow in Louisiana, however, was in the lower end of the Tensas Basin, and came principally from "backwater" around the lower end of the levee system, near Bougere Landing, and from the high water in the Red, Black, and Ouachita rivers.

For the past thirty-five years or more there had been no attempt until last year to restore the line of public levees, which at an earlier date had been built and maintained below Bougere Landing (26 miles above the mouth of Red River), so that whenever the Mississippi rose above bank-full stage below Bougere, more or less overflow took place, adding to the water that backed up to its natural level through the mouth of the Red.

But in 1902 a branch of the Texas and Pacific Railway was under construction along the right bank of the Mississippi, and its embankment was built to a higher grade than that of other parts of its line—that is, to near the level of high water in 1897—along the lowest stretch of the river bank for several miles immediately below Bougere, and the commissioners of the Fifth Louisiana levee district extended their levee line some 2½ miles to a junction with the railroad embankment. It was hoped and expected that within another year or two the railroad bank would be enlarged, so as to make it high and strong enough to serve as a levee and that the levee line south of the high-grade railroad bank could be extended, so as to bring the terminus of the levee system down to within a few miles of the mouth of Red River. It was also thought possible that meanwhile the floods might not be greater than could be held by the railroad embankment.

But, as it proved, the flood of this year came high enough to breach the railroad bank by March 14, at which date the backwater from the Red and the Ouachita was still about 7 feet lower there than in the Mississippi. The breach in the railroad bank rapidly widened and extended into the levee just built above, carrying away nearly 2 miles of it and leaving the situation practically the same as it had been for many years previous.

The resulting overflow covered over 80 per cent of Concordia Parish and a large area in Catahoula and Avoyelles parishes before any water from the Hollybrook crevasse appeared there. In fact, the water from Hollybrook did not touch the upper part of Concordia Parish at all, and before it appeared in Catahoula the backwater was already declining. The total area in these parishes overflowed by this backwater from below Bougere was about 1,325 square miles, about 30,000 acres of which in Concordia Parish was cultivable land.

It is to be noted that had there been levees down to near the mouth of Red River the backwater would have been 6 or 7 feet lower north of Bougere, and probably no cultivated land would have been flooded in Concordia or Catahoula.

NEEDS OF THE LEVEES.

The greatest need of the levees protecting Louisiana, as of most of the other levee systems, is enlargement. You already have estimates of what is needed for this purpose.

Notwithstanding the unprecedented height reached by the river this year at both the upper and lower ends of the State, there is nothing as yet apparent to indicate that the provisional grades for levees adopted by you in 1898 (shown in Plate B of your report of 1899) will prove insufficient. Had the levees been completed to "commission grade," they would have shown a margin above the water of 1903 of 2 to 5 feet everywhere from the source to the mouth of Red River and thence to the head of the system in Arkansas of not less than 3½ feet.

The form and proportions of the "standard section" recommended by your district officers November 11, 1899, still appear well devised and adequate for actual needs. Should means ever become available to make the levees wider in base and crown than this standard, it should of course give them an increased factor of safety; and such additional strength will doubtless be demanded at some future time when the sufficiency of their height has been proved by long experience.

The levees protecting Louisiana also need extension. To prevent overflow around the head of the system on Amos Bayou, the line should either be carried farther up the bayou or else the Arkansas River levees should be extended farther down. The extension of the levee at the foot of the Lower Tensas district is also necessary to limit the widespread flooding caused by water backing around the present lower end of the system near Bougere Landing. The levee line should be extended across the head of Bayou Lafourche, so as to do away with the necessity of levees on its banks. An extension is also needed on the left bank below Fort St. Philip, at least as far as Baptiste Collet Canal.

The more immediate needs are for certain large levees necessary for their continuity, which are needed on account of caving banks and crevasses; and for the raising and enlargement of the lower part of the existing line, especially where the late flood heights were in excess of previous records.

That part of the Upper Tensas district in Louisiana furnished the most notable example of both these immediate needs. A levee to close the Hollybrook crevasse will probably require 400,000 cubic yards of earthwork, and two other new levees, each requiring nearly as much, will almost certainly be required before another high-water season on account of caving banks—one at Mascot (576 miles below Cairo) and another at Biggs (604 miles below Cairo)—while the enlargement of the levees south of the Arkansas line, shown to be necessary by the extreme high water of this year, is estimated to require 900,000 cubic yards of earthwork.

The levees of the Mississippi River are still incomplete in all the States and districts. They have thus far served more efficiently than could have been expected in protecting the alluvial valley from overflow, and they give increasing promise of entire success when they are all built up to the standards of grade and section designed for them. But much remains to be done before these standards can be reached; and meanwhile every district has its annual battle behind imperfect defenses to hold back the floods poured down from over a million square miles of watershed.

In some States—and notably in Louisiana—it is physically impossible to build any levees in their own territory which can protect them against overflow by water escaping from the river in neighboring States.

And so a need for the levees more important for their complete success than any other is that the United States take charge of their construction and maintenance. This is contemplated in article 240 of the constitution of Louisiana and earnestly desired by her people.

Respectfully submitted.

HENRY B. RICHARDSON,
Chief State Engineer, Louisiana.

The MISSISSIPPI RIVER COMMISSION.
(Through Col. O. H. Ernst, Corps of Engineers, U. S. Army, President.)

APPENDIX 1.

REPORT OF CAPT. WM. B. LADUE, CORPS OF ENGINEERS, SECRETARY MISSISSIPPI RIVER COMMISSION.

MISSISSIPPI RIVER COMMISSION, OFFICE OF THE SECRETARY,
St. Louis, Mo., May 31, 1903.

COLONEL: I have the honor to submit the following report of operations under this office for the year ending May 31, 1903:

Capt. G. P. Howell, Corps of Engineers, U. S. Army, was in charge as secretary to April 22, 1903, on which date I relieved him in accordance with Special Orders, No. 81, Headquarters of the Army, Adjutant-General's Office, Washington, D. C., April 7, 1903.

The work in charge of the secretary of the Mississippi River Commission is carried on under allotments made by the Commission from appropriations for improving the Mississippi River between the Head of the Passes and the mouth of the Ohio River; from allotment for fiscal year from permanent appropriation provided by section 9 of the river and harbor act of June 13, 1902, for gauging the waters of the Mississippi River and its tributaries, and from appropriation in river and harbor act of June 13, 1902, for surveys and examinations from mouth of Illinois River to St. Louis to determine the feasibility of navigable waterway 14 feet in depth.

The allotments from the first-named appropriation are as follows:

(*1*) *Mississippi River Commission.*—Available for salaries, clerical, office, traveling, and miscellaneous expenses of the Mississippi River Commission.

(*2*) *Surveys, gauges, and observations.*—Available for survey of the Mississippi River between the Head of the Passes and its headwaters, for the establishment and maintenance of gauges, for special surveys and examinations, and for the collection and reduction of physical data pertaining to the Mississippi River.

(*3*) *Dredges and dredging.*—Available for the construction, operation, and maintenance of dredging plant for the Mississippi River from Head of the Passes to mouth of the Ohio River.

The allotment from the permanent appropriation for gauging is available for paying gauge observers and other expenses incident to maintaining gauges at specified places on the Mississippi River and its tributaries.

The appropriation for survey from mouth of Illinois River to St. Louis, in connection with deep waterway survey from Lockport, Ill., is available for surveys, borings, discharge measurements and reduction, and platting of same.

MISSISSIPPI RIVER COMMISSION.

The Mississippi River Commission held three sessions during the year, as follows:

Eighty-sixth session, June 23–26, 1902, at the president's office, St. Louis, Mo.

Eighty-seventh and eighty-eighth sessions on board the U. S. S. *Mississippi:* St. Louis, Mo., up to mouth of Illinois River, thence to New Orleans, La., November 8–16, 1902, and St. Louis, Mo., to the Passes, La., March 23–31, 1903, respectively.

Plant and outfit.—The steamer *Mississippi* has been in service with the Commission on its inspection trips, and after the November trip was docked at New Orleans and had bottom inspected and painted. From the end of November, 1902, to January 5, 1903, she was in service with gauge inspection party from Head of the Passes to Memphis. During the balance of the time this boat has been cared for and repaired at West Memphis, Ark. Plans and specifications have been prepared for replating her hull where needed, for remodeling her stern rake, and for installing new rudders and steam steering gear, and proposals invited for the work.

SURVEYS, GAUGES, AND OBSERVATIONS.

Survey of the Mississippi River.—This survey, which is authorized by the law creating the Mississippi River Commission, to extend from the Head of the Passes to the headwaters of the river, has been made with the view of obtaining accurate data for topographical and hydrographical maps for use in study of the river in connection with planning improvements. The most approved methods have mainly been used in this work.

The field work comprises secondary triangulation, precise levels, topography and hydrography. The instructions to field parties under which this work has mainly been prosecuted will be found in Report of Chief of Engineers for 1891, pages 3474–3485; these instructions for precise leveling were revised and are reprinted in Report Chief of Engineers for 1899, pages 3469–3474.

A summary of the surveys to 1896 is printed in the Report of Chief of Engineers for 1896, pages 3574–3576; the progress of the work since will be found in succeeding annual reports. The condition of the work at the beginning of the present year will be found in Supplement to the Report of Chief of Engineers for 1902, pages 32–35.

The secondary triangulation now covers the entire river from Head of the Passes to the headwaters at Lake Itasca (1,275 miles above Cairo), a distance by river of about 2,347 miles. The triangulation follows the river to Aitkin, Minn. (1,086[a]). From Brainerd, Minn., about 55 miles below Aitkin, it is carried directly across country to Lake Itasca, and thence down the river to Lake Bemidji. From Lake Bemidji a base line, whose length and azimuth are accurately determined, has been carried along the railroad down to Aitkin, thus forming a loop. This base line forms the basis of the topographic and hydrographic work along the river.

The precise levels also cover the entire river and generally follow the same lines as the triangulation, but extend down to end of the jetties at the mouth of South Pass.

A map showing the river from Brainerd, Minn., to Lake Itasca, the triangulation and precise level lines will be found in Supplement to Report of Chief of Engineers for 1901, plate 1, opposite page 232.

The lines of precise levels on the lower river were rerun in 1899 as far north as Fort Adams, Miss., and an account of the results is printed in the Report Chief of Engineers for 1900, page 4559. The extension of this releveling northward until the discrepancy between the earlier and later lines disappears is desirable.

The topography and hydrography of the river is completed from Head of the

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[a] Miles above Cairo.

Passes to Aitkin, Minn., a river distance of about 2,146 miles. This work is also completed over the Itasca Basin and a portion of the river in that vicinity. A party is now in the field carrying the work northward from Aitkin.

WORK DURING THE YEAR—GENERAL SURVEY WORK.

Tape line and precise levels.—At the beginning of the year a combined party was in the field extending the tapeline measurement and precise levels from Aitkin, Minn., to Blackberry Station, near Grand Rapids, a distance of about 80 miles. This party consisted of about 25 persons, with 5 teamsters with teams, and was in charge of Asst. Engineer George H. French, with Mr. E. L. Harman, precise leveler; Mr. George H. Wolbrecht, observer of angles and azimuth; Mr. E. E. Whitehead, computer, and recorders, surveymen, cooks, etc.

The work was closed at Blackberry Station, about 6 miles below Grand Rapids, Minn., the lower limit of previous work, June 26, 1902. This completed the triangulation and precise levels over the entire river.

For details of the work attention is invited to the report of Asst. Engineer George H. French, Appendix 1 B. The results of the tapeline work and descriptions of survey marks are given in Tables Nos. 1 and 2. The results of precise leveling are given in Table No. 3.

Topography and hydrography.—A party was organized about the middle of February, 1903, for the topographical survey above Aitkin, Minn. Camp was established at Waldeck, Minn., about 12 miles above Aitkin, Minn., and field work was begun February 16. As fully organized the party is as follows: Asst. Engineer W. G. Comber, chief of party; Asst. Engineer George H. French and Junior Engineer E. J. Thomas, topographers; Junior Engineer George H. Wolbrecht, topographer and hydrographer; 4 recorders, surveymen, cooks, teamsters, etc.; in all, about 30 persons and 4 teams.

The detailed topography has been taken on both banks, joining with the previous work just above Aitkin. The taking of soundings and slope was hindered by ice and running logs, but was taken up toward the end of April. The party is now at work in the vicinity of Grand Rapids, Minn.

Low-water survey, Cairo to mouth Arkansas River.—This survey was undertaken in compliance with resolution of the Mississippi River Commission, June 26, 1902, to determine present shore line and to furnish other data for a new edition of inch-to-mile maps for this stretch of the river, the first edition, made from surveys of twenty years ago, having been in part exhausted. Two parties were placed in the field. One party, in charge of Asst. Engineer A. T. Morrow, with the steamer *Patrol*, began work at Cairo, October 4. The second party, in charge of Asst. Engineer W. G. Comber, on the quarterboat *Illinois* with the small steamer *Mars* as tender, began work at Caruthersville, Mo. (110), on October 6. The first party, working down from Cairo, closed on the work of the other party at Caruthersville about the end of November. The second party reached Corona Landing (203), where the work was closed for the season about December 2, 1902, on account of the rapidly rising river.

For details of this survey attention is invited to the report of Asst. Engineer A. T. Morrow, Appendix 1 C.

Plant and outfit.—The floating plant now consists practically of the steamer *Patrol* and quarterboat *Illinois*, with some small boats and skiffs. The steamer *Patrol*, when not in field service, has been cared for at West Memphis. Some repairs were made and the boilers tested. The quarterboat *Illinois* was generally repaired and altered in July, 1902, for the survey party. At the end of the field work this boat was laid up at the fleet at West Memphis, where she has been cared for.

Reduction and platting of field notes.—The reduction and platting of field notes of the topography and hydrography of the season of 1901, to fill in gaps left by the survey of 1899 in the vicinity of Little Falls and Aitkin, Minn., was completed for the vicinity of Little Falls and partly done for the vicinity of Aitkin, Minn.

The field notes of the tapeline measurements and azimuth observations from Aitkin, Minn., to Blackberry Station, near Grand Rapids, Minn., were reduced and the results tabulated.

Progress was made in reducing and platting the field notes of the low-water survey from Cairo to Corona Landing, season of 1902.

Mapping.—The map of the St. Francis Basin in two sheets, scale 1 inch to 1 mile, has been completed except the shore line, which will be put in when the low-water survey below Cairo is finished.

Detail charts Nos. 213 to 218, inclusive, above Minneapolis, Minn., scale 1:5,000, were completed. Progress was made on charts Nos. 219 to 226 and 228 of the same series; chart No. 228 extends this work to about 12 miles above Brainerd, Minn.

A title sheet was prepared for the detail charts, scale 1:20,000, Cairo to Minneapolis, Minn., and also an index map in two sheets with a table of distances for the same series.

The map of Itasca Basin, scale 1:7,500, drawn for printing in colors was completed.

Published maps and charts.—Detail charts Nos. 187, 188, and 189, cities of St. Paul and Minneapolis, Minn., were published to a scale of 1:20,000. This completes this series from Cairo to Minneapolis, Minn. A title sheet and index map, the latter in two sheets, for this series of charts are now in the hands of the printer.

The map of the Itasca Basin, in three colors, was published to a scale of 1:15,000.

A list of the maps and charts published by the Commission, together with the regulations relative to their free issue to certain persons, may be found on page 35 of the Supplement to the Annual Report of the Chief of Engineers for 1902.

Gauges.—The permanent gauges, the high-water gauges, and the tide gauges have been maintained during the year. The permanent gauges have been twice inspected during the year, as prescribed by the Commission, gauges and bulletins being repaired and left in good order.

There are 38 permanent gauges, comprising 17 established by the Commission and 21 received by transfer from the United States engineer office at Vicksburg in 1901. They are distributed as follows: 25 on the Mississippi River from St. Louis, Mo., to Fort Jackson, La.; 1 on Atchafalaya River; 1 each on Arkansas, Cumberland, Tennessee, and St. Francis rivers; 3 on the Red River; 3 (including Cairo) on the Ohio River; 2 on the White River. The gauges established by the Mississippi River Commission are maintained by allotments from the appropriation for improving Mississippi River from Head of Passes to the mouth of the Ohio River; the others, by allotments from the permanent appropriation for gauging the waters of the Mississippi River and its principal tributaries, established by acts of August 11, 1888, and June 13, 1902.

The highest and lowest readings on the permanent gauges during 1902 are given in Table No. 4, with the previous highest and lowest for comparison. The highest readings on the gauges on the tributaries, for 1903 to June 30, are given in Table No. 6. A hydrograph showing the daily stages of the main river from Cairo to Fort Jackson, from June 1, 1902, to May 31, 1903, is given on plate 1.

New inclined gauges of concrete with a steel beam embedded have been constructed on the levee slope at St. Louis, Mo., and Cairo, Ill.; the former by the secretary, Mississippi River Commission; the latter by the United States Weather Bureau, the leveling and alignment being done by the secretary, Mississippi River Commission. It is intended to construct a new gauge of this type at Memphis as soon as the stage of water permits.

The gauge at Belmont, Mo., has been transferred across the river to Columbus, Ky., where it was originally. This transfer was requested by the pilots' association and was authorized by the Commission. The new gauge zero is at the same elevation as the old.

A gauge has been maintained at Aitkin, Minn., in connection with the survey of the upper Mississippi.

High-water gauges.—The high-water gauges are 185 in number, distributed on the Mississippi River from Cairo to the Head of the Passes, about 5 miles apart. Three of these gauges, A, B, and C, were established during the year. These gauges are read at times of highest water only, and supplement the regular gauges in determining the high-water slope of the river. These gauges have been inspected during the year. The maximum readings on these gauges during the flood of 1903 are given in Table No. 5. A profile of the main river from Cairo to Head of the Passes is shown on plate 2. These records, being quite complete and reliable, furnish interesting data for comparison of the flood of 1903 with the high water of previous years. The highest water this year was 1 foot below the high water of 1897 at Cairo, about the same as in 1897 at Reelfoot Landing (100 miles below Cairo), and 3 feet higher at Memphis.

Tide gauges.—The tide gauges at Biloxi, Miss., and East Bay, La., have been maintained in good order, and continuous records for the year secured. The staff gauges were connected with their bench marks in December, 1902. The Biloxi gauge was found correct, but that at East Bay had apparently settled since 1898. The observations have been adjusted for the error, as it was apparently well determined. The results will be published after the completion of the calendar year, when the series since 1899 are finally adjusted.

Bulletins.—At several of the gauge stations the bulletin frames used for displaying gauge readings for information of pilots on passing boats were in poor condition and renewals were necessary. New frames, from designs made in this office, have been erected at Cairo, Ill., Columbus, Ky., and St. Joseph, La. A drawing of the latest type of bulletin is given on plate 3.

Discharge observations.—The resolution of the Mississippi River Commission governing the measurement of the high and low water discharges of the Mississippi River and its tributaries may be found on page 36 of the Supplement to Report of Chief of Engineers for 1902.

The discharge of the Mississippi River was measured at the maximum stage during the flood of 1903 at Columbus, Ky., Helena, Ark., Arkansas City, Ark., Warrenton, Miss., and Red River Landing, La.; and at Carrollton, La., at about 0.3 foot below the maximum stage. Discharge of the tributaries was also measured at about the maximum stage during this high water at Alexandria on Red River, at Simmesport on the Atchafalaya River, below Haines Bluff on the Yazoo, and at Jonesville, La., on the Black River. The discharges of Bayou Lafourche and of Hymelia crevasse were also measured approximately.

The discharge observations were made by two parties, one in charge of Asst. Engineer William Gerig on the steamer *Venus*, and the other in charge of Junior Engineer E. L. Harman on the steamer *Patrol*. Double floats, Haskell and Price meters were used.

The reduction of all the discharge observations and meter ratings is now in progress and the results will be printed in Tables Nos. 7 and 7^a.

For additional details of gauge inspections and discharge work, attention is invited to report of Asst. Engineer Kivas Tully, Appendix 1 D.

DREDGES AND DREDGING.

Project.—On the 20th of June, 1896, the Mississippi River Commission adopted a project for obtaining and maintaining, by means of dredges, a channel in the Mississippi River below Cairo, with a width of 250 feet and a depth of at least 9 feet throughout the year, except when the river is closed by ice. This project provided for the construction and operation of 7 hydraulic dredges by the 30th of June, 1900, and for the provisional construction of two others if found necessary.

The building of this plant has formed a very important part of the work of this office and has involved the preparation of plans and specifications for the dredges themselves, for the necessary large and small tenders, pile sinkers, and other plant. Since the beginning of the construction of this dredging plant many changes have taken place in the method pursued to procure the most efficient and best designed dredges.

The first dredge was built after plans prepared by the dredging committee, and was in the nature of an experiment. While many changes in this boat were afterwards found necessary, it yet demonstrated beyond a doubt the efficiency of such hydraulic dredges for the purpose for which it was designed.

The next step was to define, in general terms, the conditions which the dredges must fulfill, leaving to the builders the details of the design. Following this course, three dredges were built. Experience was constantly gained until a point was reached where it was possible to outline with greater accuracy nearly all the details of construction. Under such specifications two more dredges were built. Under still more rigidly drawn specifications, another, the seventh, a self-propelling dredge, was placed under contract in 1898. This dredge was completed and delivered to the United States in August, 1900. The eighth and ninth dredges, also self-propelling, were placed under contract in June, 1899, and were completed and delivered to the United States in July, 1901.

CONSTRUCTION, ALTERATION, AND REPAIRS TO PLANT.

Dredge Alpha.—The machinery of this dredge has been offered for sale in accordance with resolution of Mississippi River Commission, June 26, 1902.

Dredge Beta.—This dredge was returned to the fleet by the officer in charge of the work at South Pass on November 5, 1902. During the winter the hauling engines have been rebuilt and strengthened, and the foundations of the Heine water-tube boilers strengthened with concrete. A new set of grate bars was procured and new edge plates put on the main pump. The officer in charge of the work at South Pass having requested that the *Beta* be returned to him, on January 28 she left the fleet in tow of the *Sachem*. At the date of this report she is still at South Pass.

Dredge Gamma.—New edge plates were required for the main pumps. The hardened pump liners did not require replacing. The engines and boilers were thoroughly overhauled and put in condition for work.

Dredge Delta.—The new suction head, arranged for dredging downstream as well as up, was tested during the year and was found to work well. Owing to the fact that the winding engines were not reversing, however, the dredge proved difficult to control when working downstream. Reversing gears for these engines have been procured and are now being put in place. With this improvement it is hoped that the dredge can be controlled while working downstream, and that the method will prove a success. Screen bars have been placed over the downstream opening of suction head and the hoisting rigging remodeled. The jet pumps have been much more satisfactory in operation than the mechanical cutters with which the dredge was first equipped. The main engine has been braced up below. Some painting was done and minor repairs were made.

Dredge Epsilon.—The repairs to boilers and repairs to shroud of pump runner under way at date of the last annual report were completed, and various minor repairs made. This dredge did very little work during the past season, but the experience gained since the runner was changed to the inclosed type shows the advantages of this type in economy of repairs.

Dredge Zeta.—New edge plates were put on the main pump. The pump on this dredge and that on the *Epsilon* were originally alike, and it is proposed to inclose the *Zeta's* runner as was done on the *Epsilon.* This has not yet been done. The boiler repairs under way at date of last report were completed.

Dredge Iota.—This is the first of the self-propelling dredges of the Commission. The repairs to the suction head referred to in the last annual report were completed. A shroud was placed on the pump runner, converting it into one of the inclosed type, and greater economy in repairs is expected. Derricks for handling the piles were put up. The ice plant and electric-light engine have been thoroughly overhauled, the wheelhouses enlarged, and other repairs made. While dredging at Hathaways Crossing (103), September 27, the dredge was run into by passing steamers and both mooring piles and the ends of both hauling cables broken.

Dredge Kappa.—Self-propelling dredge. The suction head was changed to conform to that of the *Iota* as altered. The main engines and the electric-light engines have been braced up, and derricks erected for handling the piles. Traveling cranes have been installed over the main pump and engines. New engines for raising the suction head were set up. While dropping back to change cuts, September 18, the end of the ponton line struck the bank and two of the universal couplings of the pipe line were broken, and a third probably cracked. Changes in the design of this universal coupling have been made, rendering it stronger and less liable to injury. Minor repairs have been made.

Dredge Henry Flad.—Self-propelling dredge. Alterations of the suction head to conform to the *Iota* and the *Kappa* were made during the year, new engines for raising the suction head installed, and derricks for handling the piles set up. The main engines have been braced up to check vibration, and traveling cranes installed over them. Universal couplings of pipe line have been remodeled like those of the *Kappa*, and painting and minor repairs carried on.

New self-propelling dredge.—The preparation of the plans for the new self-propelling dredge to be built under the direction of the Commission has been taken up.

Large tenders.—Contract was entered into January 30, 1903, with Ed. J. Howard, of Jeffersonville, Ind., for rebuilding the upper works of the *Wynoka.* This work is now in progress at Mr. Howard's yards and is reported as 60 per cent completed. The renewal of the plumbing is also in progress, and the dynamo is being repaired by the makers. It is hoped to complete the repairs and fitting up of the *Wynoka* in time to use her this season.

The boilers of these tenders have given trouble by the shearing of the rivets in the vertical seam, due, it is thought, to the excessive contraction in the great length of the sheets. To remedy this, annular pieces are being cut out near the center of each sheet, and new plates riveted in the openings, thus giving five vertical seams instead of one. This work is completed on the *Leota* and the *Wynoka*, well under way on the *Choctaw*, and begun on the *Nokomis.* Other minor repairs were made to these tenders to get them in proper condition for the season's work.

Steamer Search.—This steamer was floated onto the bank at the last high water this spring, and blocked up. An examination of the hull showed both planking and framing in bad condition. It is now being entirely renewed. Other minor repairs have been made.

Small tenders.—Minor repairs have been made.

Pile sinkers and barges.—Repairs necessary to keep these boats serviceable have been made.

For additional details of repairs during the year, attention is invited to report of Asst. Engineer F. B. Maltby, Appendix 1 E.

DREDGING OPERATIONS ON THE LOWER MISSISSIPPI RIVER BETWEEN CAIRO, ILL., AND HEAD OF THE PASSES.

These operations include the care and repair of plant, testing of dredges, and operation of the plant during the low water season.

A statement of the general principles which have governed the general conduct of dredging operations may be found in the report of the Chief of Engineers, U. S. Army, for 1898, pages 3166-3169, and in the report of the Chief of Engineers, U. S. Army, for 1900, page 4564.

During the low water season of 1902 the 8 dredges of the Commission were all in commission; but 2 of these, the *Beta* and the *Zeta*, did no work, while the *Epsilon* worked but twenty-four hours. The dredges were assigned to different stretches of the river. Three survey parties were kept in the field, and surveys were made of all bars where trouble was anticipated. Frequent surveys were made of those bars where dredging was done, to observe the effect of the dredging. These surveys served to locate the areas of shoal water and to enable the location of the channels to be intelligently made. Frequent inspections were made of that part of the river where shoals are known to exist, and all crossings sounded. The greatest possible publicity was given to information obtained, and all channels were located by easily distinguishable marks.

Dredge Beta.—This dredge was received from the officer in charge of the work at South Pass on November 5 at Lake Providence, La. (542). Reports of shoal water at this place were shown by surveys to be unfounded, and the *Beta*, not being required for work at any other point, left on November 22 for West Memphis, Ark., and was laid up on December 4.

Dredge Gamma.—This dredge left the fleet August 28. On September 21 she began dredging at Island 20 (127) and worked there without interruption till September 25, when a channel of satisfactory dimentions had been formed, which maintained itself through the season. Between September 29 and 30, and again between November 3 and 6 some dredging was done at Island 18 (119), after which the drege was laid up, November 10.

Dredge Delta.—This dredge left the fleet August 20, and on August 26 began work at Last Chance Crossing (166). Work was suspended on September 2 on account of a rising river and resumed on September 19. Work at this locality was completed September 29, and the channel thereafter followed the dredged cut and no further trouble was experienced. Between November 5 and November 19 the dredge was at work at Peters Crossing (270) with slight interruptions, and between November 21 and 26 at Graves Bayou (250). At each of these bars the work was successful.

Dredge Epsilon.—This dredge left the fleet September 25 and worked for about 24 hours at Miss Hickmans Crossing (131) September 28-29. She did no more dredging during the season, and was retired from the field November 18.

Dredge Zeta.—This dredge was put in commission September 15, but did not leave the fleet. She was laid up October 31.

Dredge Iota.—This dredge left the fleet September 18, and began work at Hathaways Crossing (103) September 24. Work was stopped September 27, and owing to a rise in the river was not resumed till November 3. From November 3 to November 8, and from November 10 to November 13, and again from November 16 to November 20 work was done, being completed at the latter date. On November 27 the dredge was retired from the field. Owing to the width of the river and the length of the crossing it was difficult for steamers to keep in the dredged channel at this point, but the operations were successful in opening and maintaining a channel of the required width and depth.

Dredge Kappa.—This dredge left the fleet August 19 and began work at Bixbys Towhead (83) August 30. Work was suspended September 6 on account of a rise in the river and resumed September 14. From September 14 to September 18, and from September 21 to 24 the dredge was at work. High water prevented further operations until October 28, when work was resumed and continued till November 7, two days being lost cleaning boilers. November 8 to 11 the dredge removed a mud lump at Silver Top Bar (84), and November 13 to 15 she worked at Darnells Bar (79), retiring from the field November 24.

Dredge Henry Flad.—This dredge left the fleet September 22, and began work on the bar which had formed across the upper end of the Memphis wharf front. Work was continued here until the 30th, when the dredge returned to the fleet to await a lower stage. On November 5 she again left the fleet, and began work at Ashley Point (274) on the 6th. Dredging was continued with delays due to cleaning boilers and repairs to machinery until the 16th. The dredge was then returned to the fleet for repairs, and was laid up November 22.

A summary of the dredging operations, distribution of time and expenditures will be found in tables Nos. 8 and 9. For further details, attention is invited to the report of Asst. Engineer F. B. Maltby, Appendix 1 E.

DISCUSSION OF RESULTS.

Referring to the hydrograph on plate 1, it will be seen that the season of 1902 was a favorable one. The lowest stages and the fluctuations at Cairo and Memphis are shown by the following readings:

CAIRO.

Date.	Reading.	Date.	Reading.
August 20	15.4	October 12	20.0
September 1	18.8	November 8	9.7
September 26	7.3	December 27	39.0

MEMPHIS.

Date.	Reading.	Date.	Reading.
August 23	9.3	October 14	12.7
September 4	12.0	November 10	4.0
September 29	3.0	December 29	30.0

The work done by the dredges was less than usual, and no crossings were particularly troublesome.

The results of the dredging operations are shown on plates 4 to 29, to which attention is respectfully invited. The soundings on these plates are reduced to mean low water, and depths greater than 9 feet below mean low water are indicated by parallel ruling. So far as known, there was at no time less than 9 feet of water in the channel during the season. The plates are believed to show clearly what was accomplished and to indicate the general rules which governed the location of dredged cuts. The first plate of each series shows the total area afteawards dredged during the season, but the subsequent plates show only the areas dredged prior to that survey.

Below will be found a brief discussion of the results obtained at each locality where dredging was done,

Vicinity of Point Pleasant (*79–83*)—Plates 4–10.—This vicinity, as usual, was troublesome this season. The river in this reach is broad and the channel consequently unstable and shallow. The conditions at Darnells Crossing (80) before and after dredging are shown on plates 4 and 5. Work here was not required until late in the season (November 13–15) and a comparatively few hours work sufficed to open a channel that remained open the rest of the season. At Bixbys Towhead (83) more work was done than at any other locality during the season. As shown on plate 6, a neck 2,250 feet wide between the 9-foot contours had to be cut through. This location, about a mile below the steamboat channel at the time, was selected from a study of the survey and the indications on the spot. The results justified the selection in a marked manner, as the dredged channel constantly improved while the old steamboat channel became impassable. As the river fell after each rise dredging was needed, but at no time was there less than 11 feet in the channel, and at the end of the season it was in a satisfactory condition. Plates 7 to 10, inclusive, show the results of the work.

Silver Top Bar (*84*)—No plate.—A small amount of dredging was done here to remove a mud lump from the channel.

Hathaways Crossing (*103*)—Plates 11–13.—Next to the vicinity of Point Pleasant, this crossing was the most troublesome this season. Plate 11 shows the conditions before any work was done. Plate 12 shows the dredged channel to have been filled in by the rise that took place October 10–15. Plate 13 shows the conditions after the second dredging. The channel remained in the dredged cut during the remainder of the season.

Island No. 18 (*119*)—Plates 14–16.—But a small amount of work was required here to remove a lump in the channel. Plate 14 shows the conditions after dredging the first time. The channel having shoaled slightly after the rise in October, as shown in plate 15, dredging was resumed, the results being shown in plate 16.

Island No. 20 (*127*)—Plates 17-18.—As shown on plate 17, only a narrow neck between the 9-foot contours required cutting through. This was accomplished in less than four days, the results being shown on plate 18. The channel was permanent for the rest of the season.

Miss Hickmans Crossing, or foot of Island No. 21 (*131*).—Plates 19 and 20 show conditions before and after dredging at this point. The work was completed in less than twenty-four hours.

Last Chance Crossing (*166*)—Plates 21-23.—At the beginning of the season, as shown on plate 21, the channel was crooked. It was straightened, as shown on plate 22. Almost two weeks later dredging again became necessary, and the results thirteen days after are shown on plate 23, which shows a broad and deep channel down the dredged cut. This plate also shows that a second channel was opened above the dredged channel, but the latter remained permanent during the rest of the season.

Memphis Front (*230*)—No plate.—The dredging here was done to clear away a bar that had encroached upon the wharf front. The operations were successful, about 600 feet of additional wharf front being made available, with deep water up to it.

Graves Bayou (*250*)—Plates 24-25 show the conditions before and after the dredging at this locality. The channel remained in the dredged cut.

Peters Upper Crossing (*270*)—Plates 26-27.—As shown on plate 26, a location coming into the upper pool above its lower end was chosen, involving a cut 3,500 feet long. The results were satisfactory, the channel remaining in the dredged cut, as shown on plate 27, ten days after dredging.

Peters Lower or Ashley Point Crossing (*274*)—Plates 28-29.—As shown in plate 28, the cut was made from the lower end of the upper pool. Plate 29 shows the channel through the dredged cut, where it remained during the remainder of the season.

No dredging was required this year at Cherokee Crossing (90), Reelfoot (99), Luxora (161), Island 34 (179), Presidents Island (233-235), or Fleeces Crossing (243), all of which have given trouble in past years. On the other hand, Hathaways (103), Last Chance (166), Graves Bayou (250), and Peters Towhead (270-1) required more work than usual, while Ashley Point (274) was a new place this year. The amount of material moved by the dredges is estimated under the same suppositions as heretofore—that the width of each cut is the width of the dredge's suction; that the depth is as determined by the soundings, and that the side slopes are 1 on 2¼. The result of this calculation is 813,380 cubic yards. In 1901 the amount was 1,666,465; in 1900, 1,145,599; and in 1899, 1,612,223 cubic yards.

For additional details attention is invited to the report of Asst. Engineer F. B. Maltby, Appendix 1 E.

TESTS OF DREDGES.

During the past working season exhaustive tests were made of the boilers, engines, and pumps of all the dredges except the *Beta*, which was not available. These tests were undertaken under resolution of the Commission and were conducted in accordance with the following directions from the committee on dredges and dredging dated July 24, 1902:

"1. Such tests shall be made as may be necessary to determine the efficiency of boilers, engines, and sand pump of each of the dredges. The relative efficiency of the several types of jet pumps, with due consideration of the results required in economical dredging work, should also be carefully determined.

"2. As a basis for determining the mechanical efficiency of engines and pumps under working load, it is necessary to first determine their frictional horsepower when running at normal speed without load.

"3. The pump tests shall be made by pumping water with the intake submerged to the normal depth and the pump running at normal speed, and also at known speeds both higher and lower than the normal, to ascertain the effect of variations in speed.

"4. In order to ascertain, as far as practicable, the effect of the form of suction head, tests shall be made both with and without the suction head, where these are so attached as to be readily removable.

"5. Each test shall embrace the determination of the indicated horsepower of engines, the number of revolutions of pump per minute, the velocity of flow in suction and discharge pipe, the suction and discharge pressures.

"6. In addition to the pressure gauges now in use mercury manometers should be attached to suction and discharge pipes near pump for the accurate determination of suction and discharge pressures.

"7. The velocity of flow in suction and discharge pipe shall be carefully measured, and their determinations should be made at several points in the cross section of discharge pipe, so as to determine whether or not the whole of the discharg section is effective under normal pumping conditions. This test can, however only be made when pumping sand, but it would not interfere materially with th regular field work if done when dredges are in operation. Pitot's tubes ar recommended for use in making velocity observations.

"8. The loss of head due to friction in discharge pipe shall be determined. I is also desirable to carry this investigation further, if found practicable, so as t include the effect of curved sections, rough joints, etc.

"9. It is also desirable to measure, as far as practicable, the relative efficienc of the double and single intake to ascertain whether the flow of two columns o water from opposite directions and meeting at the center of the pump tends t materially reduce the efficiency.

"10. In conducting the above-required investigations, other lines of inquiry wil doubtless be suggested, and if they promise results of value they should be fol lowed up.

"11. When the required observations have been completed they shall be carefully studied and compared, with a view to determine the most efficient type o engine and pump now in use, and how the best of these could be improved upon in future construction.

"12. The results of the above investigations shall be embodied in a report giving in detail the type and form of boilers, engines, and pumps examined, and the observations made in each case, with a summary showing from the results which typ or combination of types is the most efficient and best for the conditions met with in the Mississippi River.

"13. It is intended that the investigations and experiments called for above wil be made at such times as the dredges are not otherwise employed, as when lying at the bank waiting for suitable stage of water or at the close of the coming dredging season before being laid up for the winter. It is therefore desirable to to have such preparatfons made in the way of instruments and measuring appliances and attachments as may be deemed necessary before going into the field."

These tests were conducted by Mr. F. B. Maltby, assistant engineer, whose report thereon is printed in Appendix 1 F. The services of Prof. W. B. Gregory, of Tulane University, New Orleans, La., were secured to assist Mr. Maltby during a portion of the tests and also to review the information obtained. A report on his part of the work was submitted by Professor Gregory and is printed as Appendix 1 G. To these reports attention is respectfully invited fcr full details of the methods employed, results obtained, and conclusions drawn therefrom.

Supplementary tests of pump runners of varying numbers of blades in the same pump are now being made, and a report will be submitted when the tests are completed. The *Beta* will also be tested when available.

SURVEYS FOR 14-FOOT WATERWAY, MISSISSIPPI RIVER, FROM THE MOUTH OF THE ILLINOIS RIVER TO ST. LOUIS, MO.

The river and harbor act of June 13, 1902, provided that the Mississippi River Commission shall make such surveys, examinations, and investigations as may be required to determine the feasibility of and to prepare and report plans and estimates of cost of a navigable waterway 14 feet in depth from the mouth of the Illinois River by way of the Mississippi River to St. Louis, Mo., in connection with a 14-foot waterway from Lockport, Ill., to St. Louis, Mo. The required survey has been partially made under the direction of the Secretary, in accordance with project of Capt. G. P. Howell, approved by the Chief of Engineers, United States Army, August 16, 1902. A survey of the river between the high-water banks was begun at the mouth of the Illinois River by a party in charge of Asst. Engineer A. T. Morrow, on the steamer *Patrol* and the quarterboat *Illinois*, on August 28, 1902, and completed to the head of Arsenal Island, St. Louis, on September 30. The field notes have been reduced and platted, and the working sheets drawn in pencil, on a scale of 1 to 4,800, covering ten sheets. The stage of water was, unfortunately, quite high during a portion of the time of the field work, and it will be necessary to obtain some additional data at the next low water. Further surveys of the topography of the east bank between Alton and St. Louis and of the west bank from near Grafton to the mouth of the Missouri River are also desired. It is proposed to put a party in the field during the next low-water season to secure this information, and to make borings and additional discharge observations.

PLATE 4.

MISSISSIPPI RIVER COMMISSION.

MAP OF

DARNELLS POINT CROSSING,

Made under direction of

CAPTAIN G. P. HOWELL,

Corps of Engineers, U. S. A., Secretary.

Survey of November 12, 1902.

ONE DAY BEFORE DREDGING.

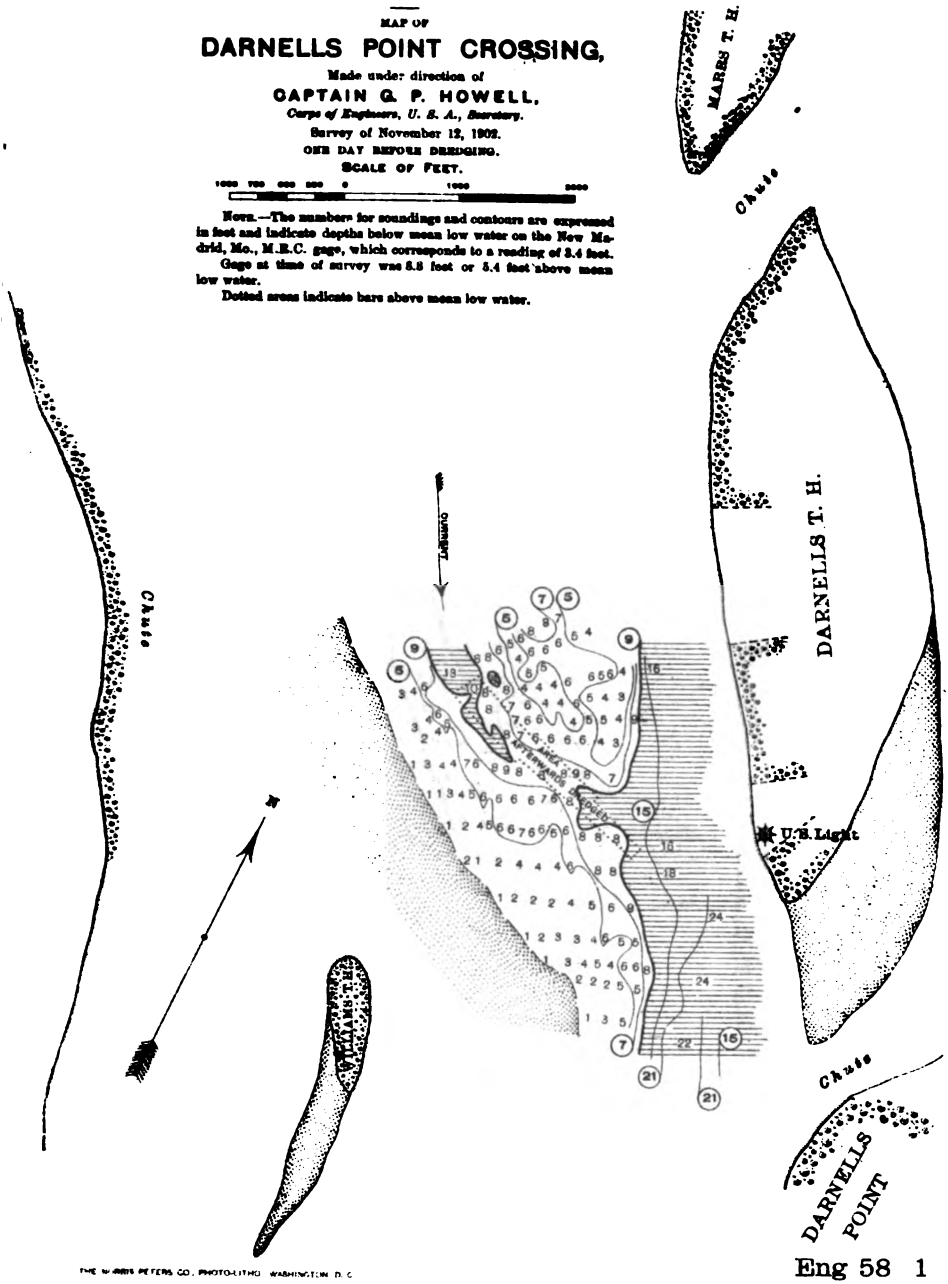
SCALE OF FEET.

1000 750 500 250 0 1000 2000

NOTE.—The numbers for soundings and contours are expressed in feet and indicate depths below mean low water on the New Madrid, Mo., M.R.C. gage, which corresponds to a reading of 3.4 feet.

Gage at time of survey was 8.8 feet or 5.4 feet above mean low water.

Dotted areas indicate bars above mean low water.



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MISSISSIPPI RIVER COMMISSION.

MAP OF

DARNELLS POINT CROSSING,

Made under direction of

CAPTAIN G. P. HOWELL,

Corps of Engineers, U. S. A., Secretary.

Survey of November 21, 1903.

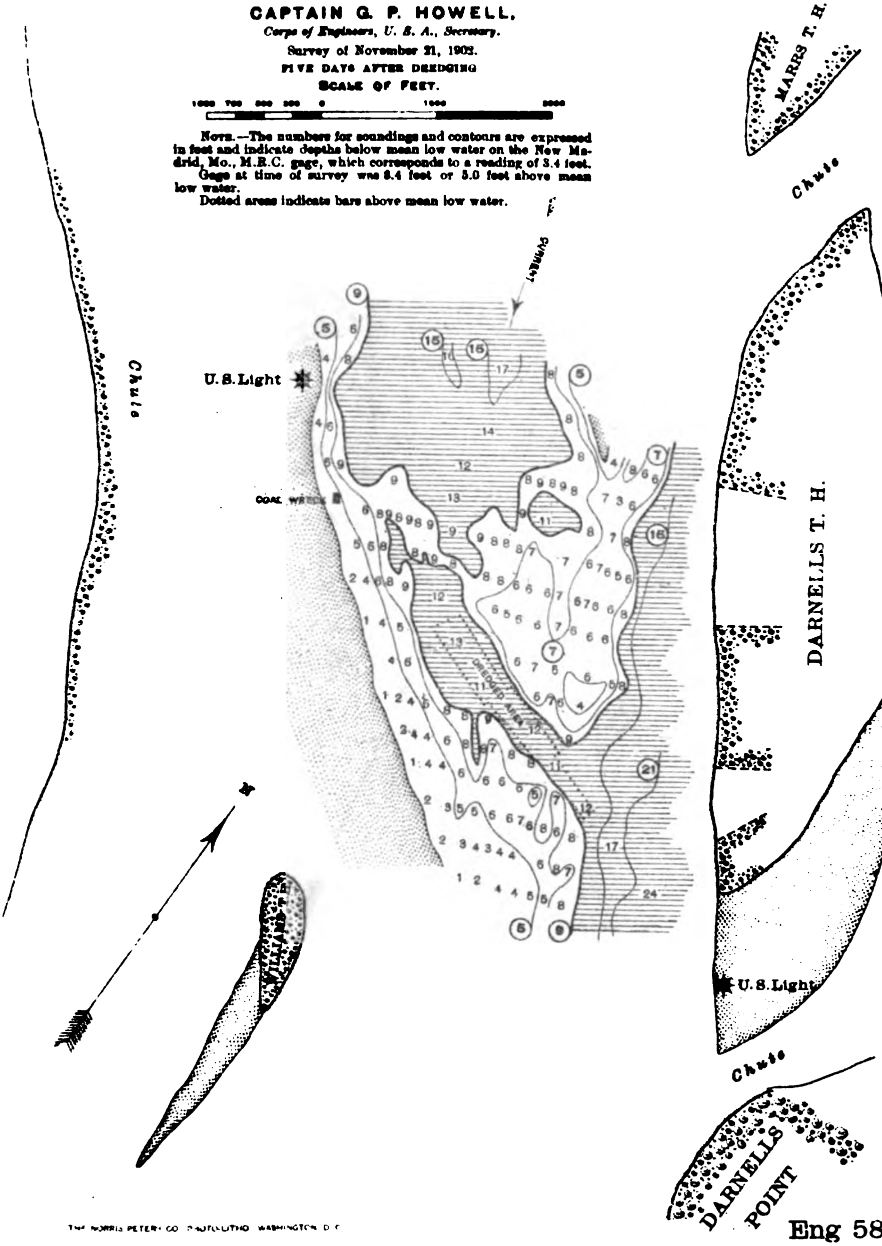
FIVE DAYS AFTER DREDGING

SCALE OF FEET.

Note.—The numbers for soundings and contours are expressed in feet and indicate depths below mean low water on the New Madrid, Mo., M.R.C. gage, which corresponds to a reading of 3.4 feet.

Gage at time of survey was 8.4 feet or 5.0 feet above mean low water.

Dotted areas indicate bars above mean low water.



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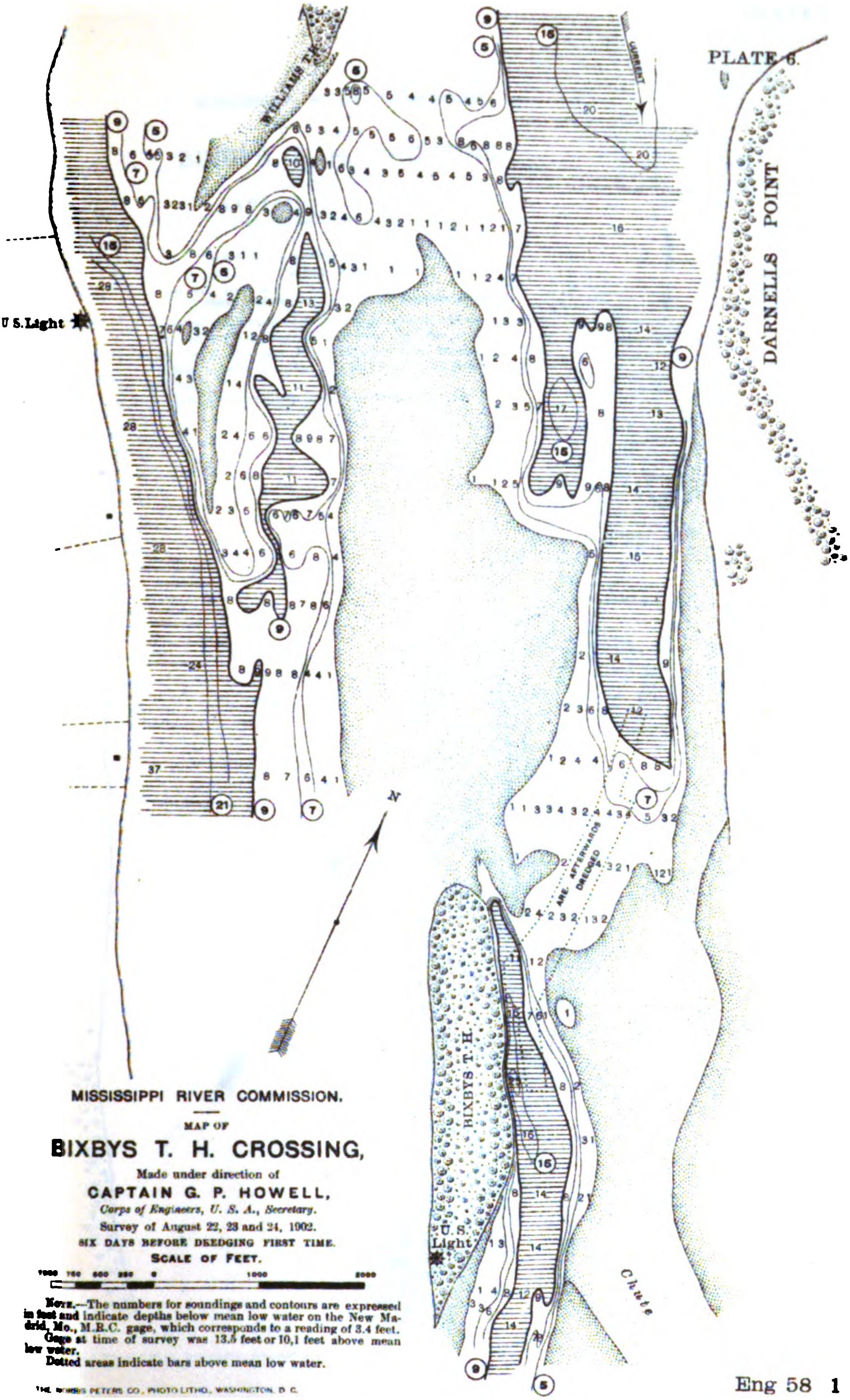

MISSISSIPPI RIVER COMMISSION.

MAP OF

BIXBYS T. H. CROSSING,

Made under direction of

CAPTAIN G. P. HOWELL,

Corps of Engineers, U. S. A., Secretary.

Survey of August 22, 23 and 24, 1902.

SIX DAYS BEFORE DREDGING FIRST TIME.

SCALE OF FEET.

Note.—The numbers for soundings and contours are expressed in feet and indicate depths below mean low water on the New Madrid, Mo., M.R.C. gage, which corresponds to a reading of 3.4 feet. Gage at time of survey was 13.5 feet or 10,1 feet above mean low water.

Dotted areas indicate bars above mean low water.

THE NORRIS PETERS CO., PHOTO LITHO., WASHINGTON, D. C.

PLATE 7.

MISSISSIPPI RIVER COMMISSION.

MAP OF

BIXBYS T. H. CROSSING,

Made under direction of

CAPTAIN G. P. HOWELL,

Corps of Engineers, U. S. A., Secretary.

Survey of September 9, 1902.

THREE DAYS AFTER DREDGING FIRST TIME.

SCALE OF FEET.

NOTE.—The numbers for soundings and contours are expressed in feet and indicate depths below mean low water on the New Madrid, Mo., M.R.C. gage, which corresponds to a reading of 3.4 feet.

Gage at time of survey was 14.7 feet or 11.3 feet above mean low water.

Dotted areas indicate bars above mean low water.

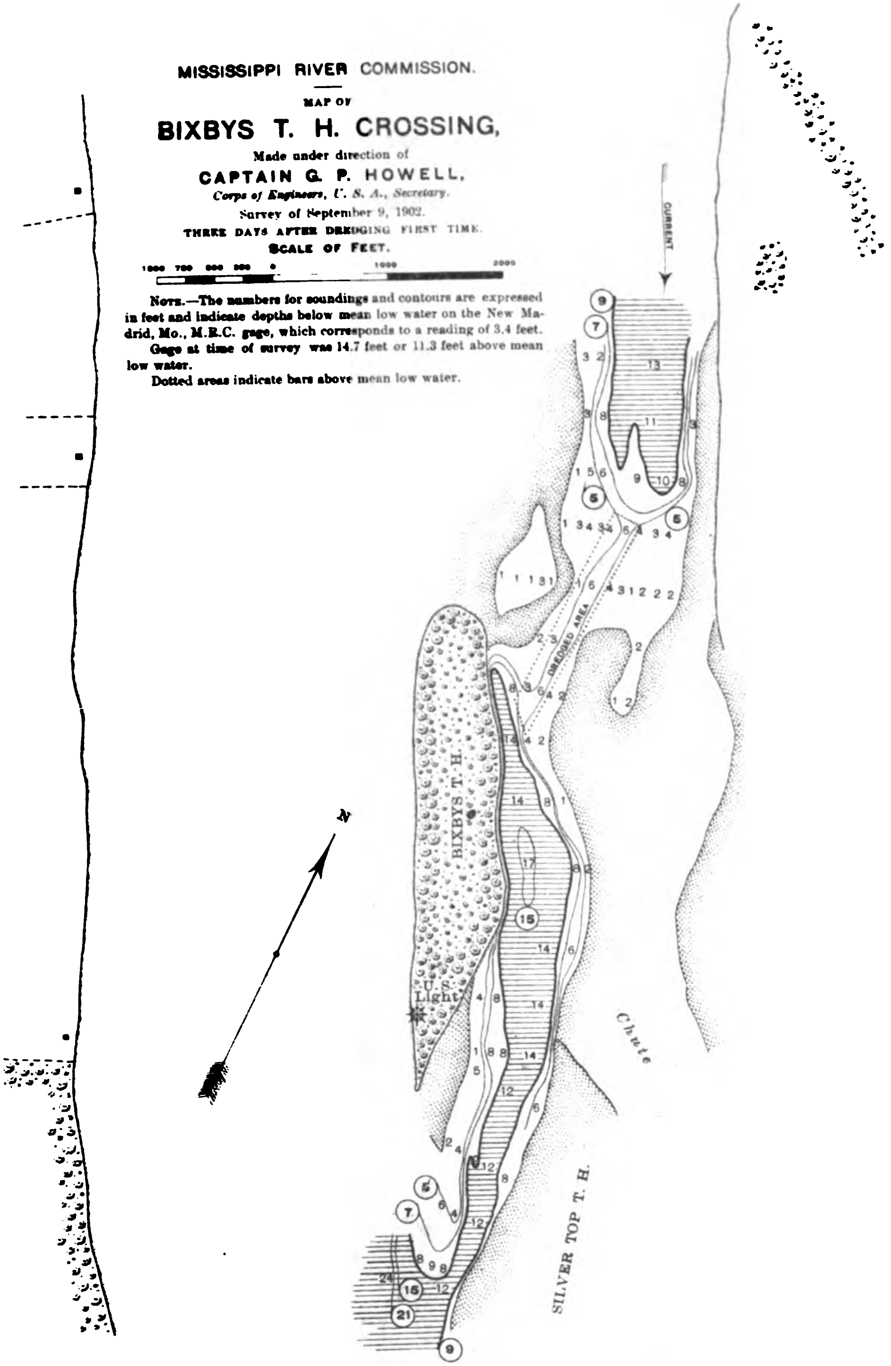

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PLATE 8.

MISSISSIPPI RIVER COMMISSION.

MAP OF

BIXBYS T. H. CROSSING,

Made under direction of

CAPTAIN G. P. HOWELL,

Corps of Engineers, U. S. A., Secretary.

Survey of September 28, 1902.

FOUR DAYS AFTER DREDGING SECOND TIME.

SCALE OF FEET.

NOTE.—The numbers for soundings and contours are expressed in feet and indicate depths below mean low water on the New Madrid, Mo., M.R.C. gage, which corresponds to a reading of 3.4 feet.

Gage at time of survey was 7.5 feet or 4.1 feet above mean low water.

Dotted areas indicate bars above mean low water.

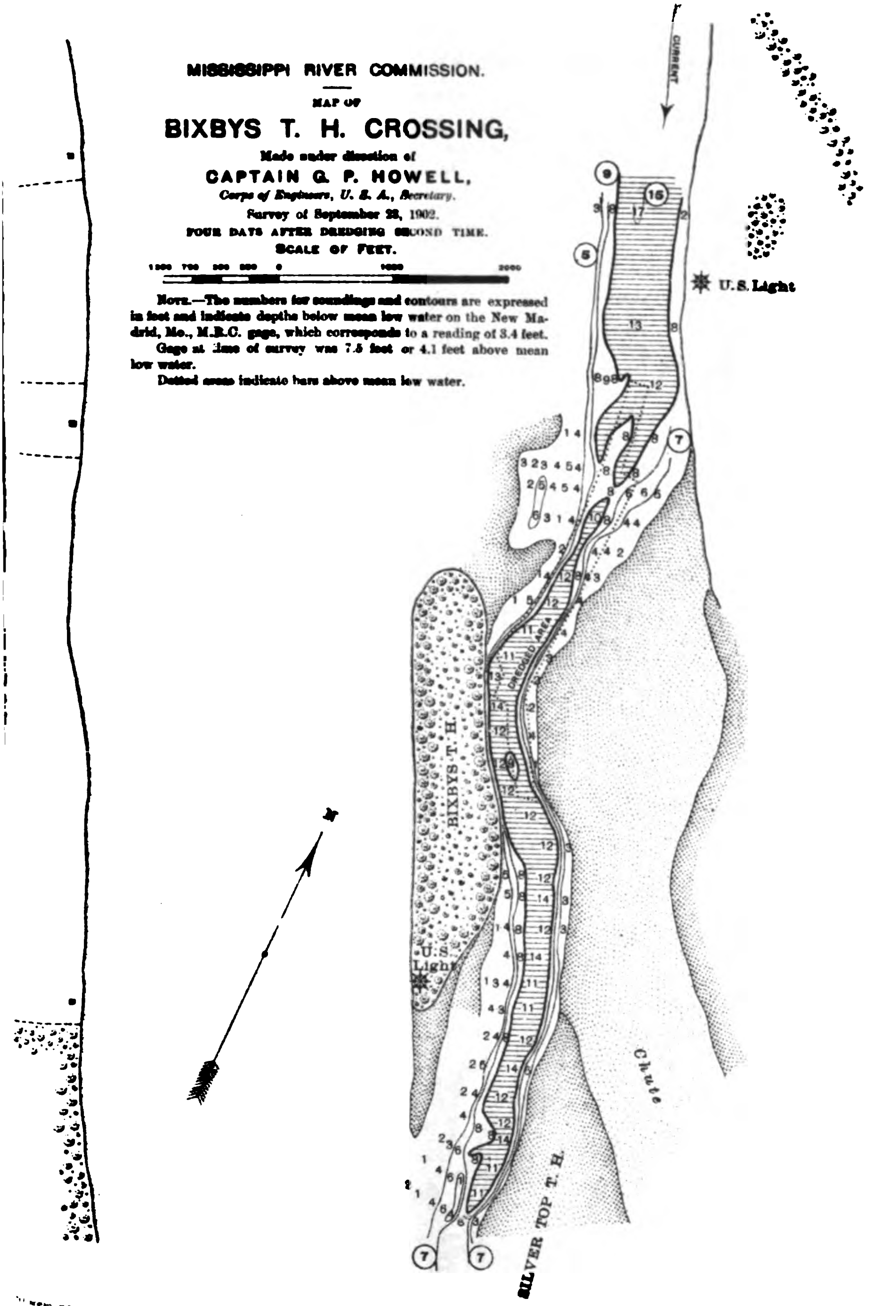

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PLATE 9.

MISSISSIPPI RIVER COMMISSION.

MAP OF

BIXBYS T. H. CROSSING,

Made under direction of

CAPTAIN G. P. HOWELL,

Corps of Engineers, U. S. A., Secretary.

Survey of October 27, 1902.

ONE DAY BEFORE DREDGING THIRD TIME.

SCALE OF FEET.

NOTE.—The numbers for soundings and contours are expressed in feet and indicate depths below mean low water on the New Madrid, Mo., M.R.C. gage, which corresponds to a reading of 3.4 feet.

Gage at time of survey was 14.0 feet or 10.6 feet above mean low water.

Dotted areas indicate bars above mean low water.

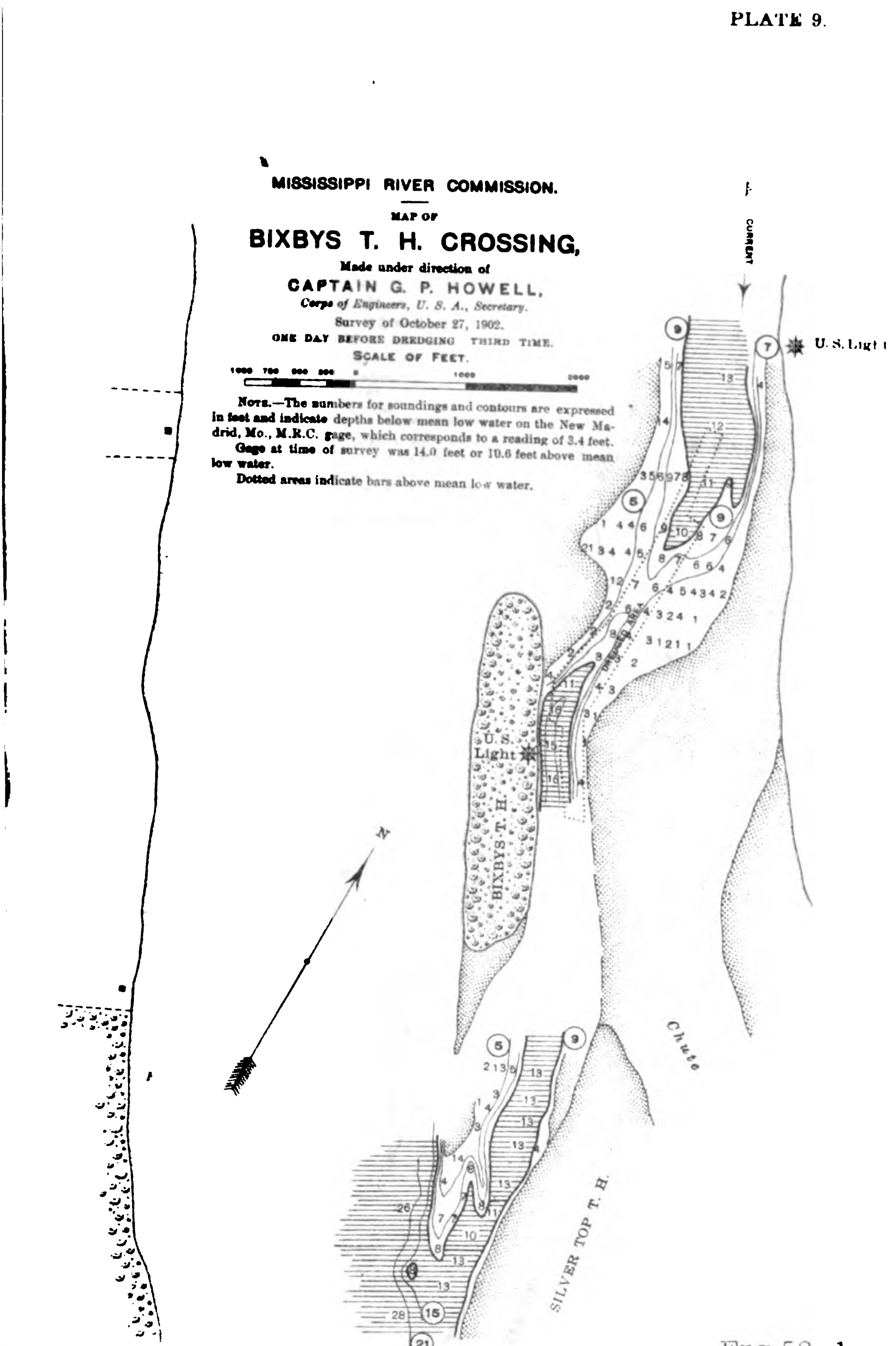


PLATE 10.

MISSISSIPPI RIVER COMMISSION.

MAP OF

BIXBYS T. H. CROSSING,

Made under direction of

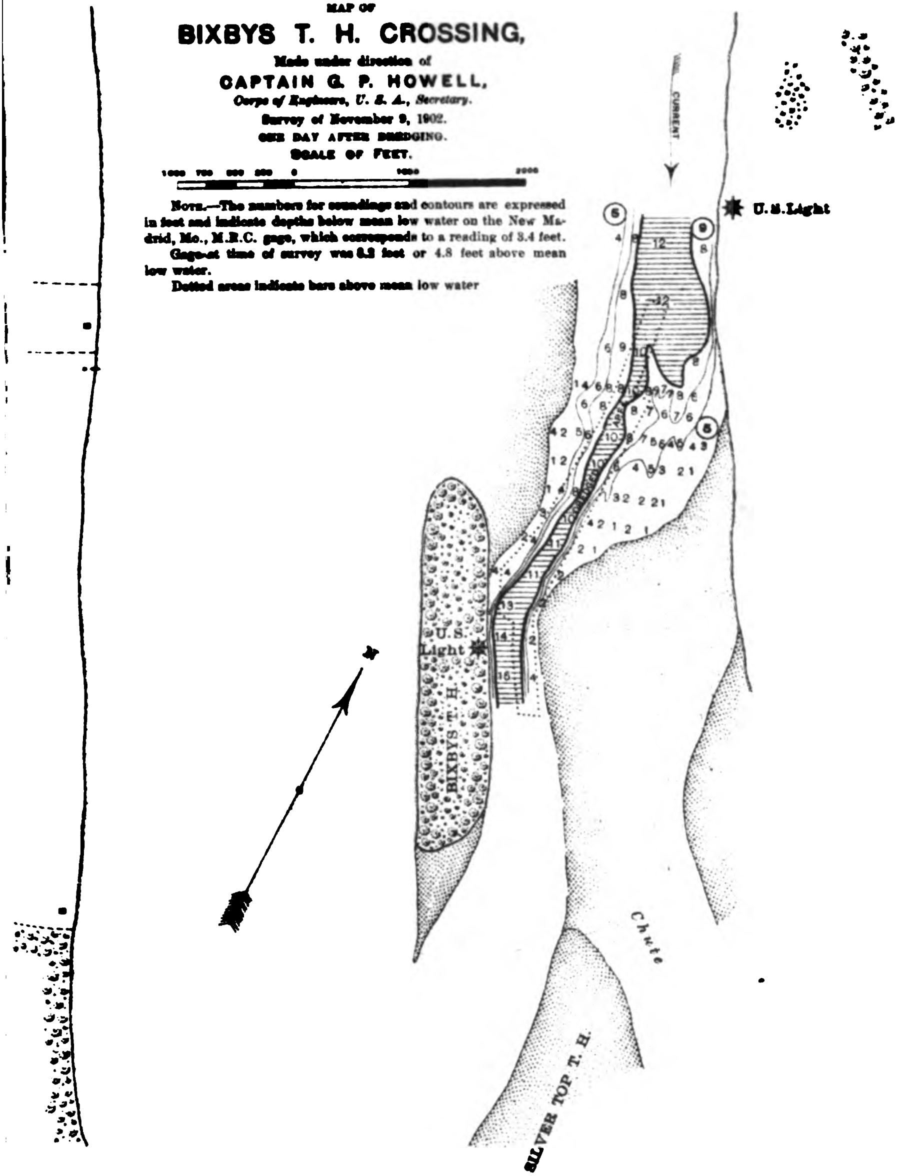
CAPTAIN G. P. HOWELL,

Corps of Engineers, U. S. A., Secretary.

Survey of November 9, 1902.

ONE DAY AFTER DREDGING.

SCALE OF FEET.



NOTE.—The numbers for soundings and contours are expressed in feet and indicate depths below mean low water on the New Madrid, Mo., M.R.C. gage, which corresponds to a reading of 3.4 feet.

Gage at time of survey was 8.2 feet or 4.8 feet above mean low water.

Dotted areas indicate bars above mean low water

THE NORRIS PETERS CO., PHOTO-LITHO., WASHINGTON, D. C.

PLATE 11.

MISSISSIPPI RIVER COMMISSION.

MAP OF

HATHAWAY CROSSING,

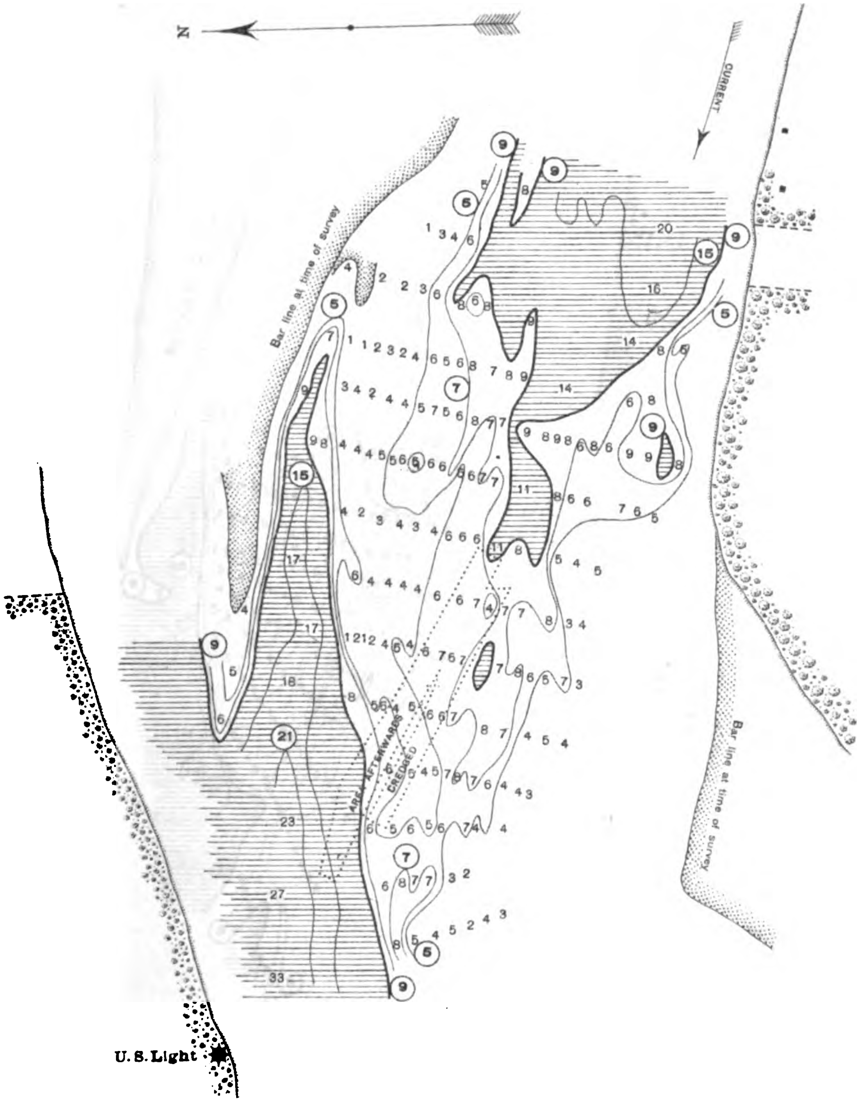
Made under direction of
CAPTAIN G. P. HOWELL,
Corps of Engineers, U. S. A., Secretary.
Survey of September 20, 1902.
TWO DAYS BEFORE DREDGING.
SCALE OF FEET.

1000 750 500 250 0 1000 2000

NOTE.—The numbers for soundings and contours are expressed in feet and indicate depths below mean low water on the Cottonwood Point, Mo., M.R.C. gage, which corresponds to a reading of 0.5 feet.

Gage at time of survey was 5.9 feet or 5.4 feet above mean low water.

Dotted areas indicate bars above mean low water.



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THE NORRIS PETERS CO., PHOTO-LITHO., WASHINGTON, D. C.

MISSISSIPPI RIVER COMMISSION.

MAP OF

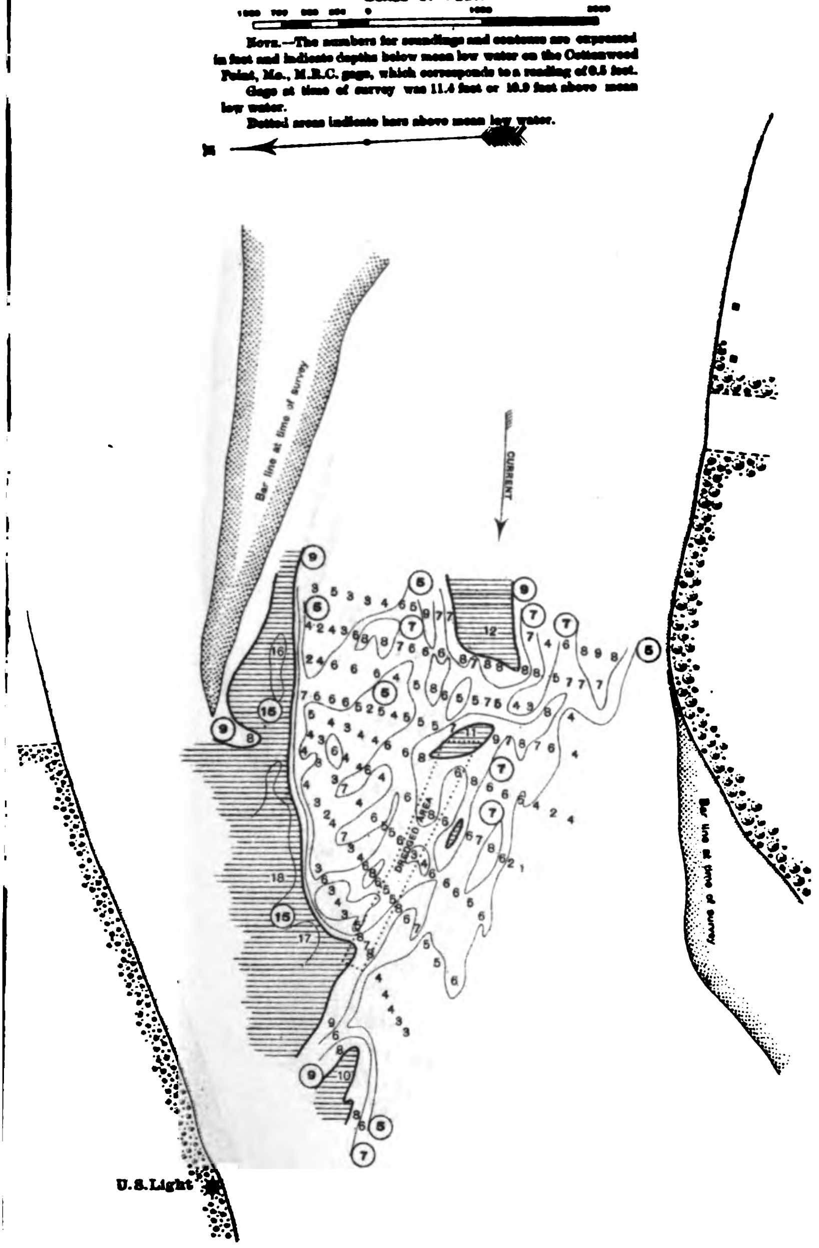
HATHAWAY CROSSING,

Made under direction of
CAPTAIN G. P. HOWELL,
Corps of Engineers, U. S. A., Secretary.,
Survey of October 28, 1902.
FOUR DAYS BEFORE DREDGING SECOND TIME.
SCALE OF FEET.

NOTE.—The numbers for soundings and contours are expressed in feet and indicate depths below mean low water on the Cottonwood Point, Mo., M.R.C. gage, which corresponds to a reading of 0.5 feet.

Gage at time of survey was 11.4 feet or 10.9 feet above mean low water.

Dotted areas indicate bars above mean low water.



MISSISSIPPI RIVER COMMISSION.

PLATE 13.

MAP OF

HATHAWAY CROSSING,

Made under direction of

CAPTAIN G. P. HOWELL,

Corps of Engineers, U. S. A., Secretary.

Survey of November 28, 1896.

TWO DAYS AFTER DREDGING SECOND TIME.

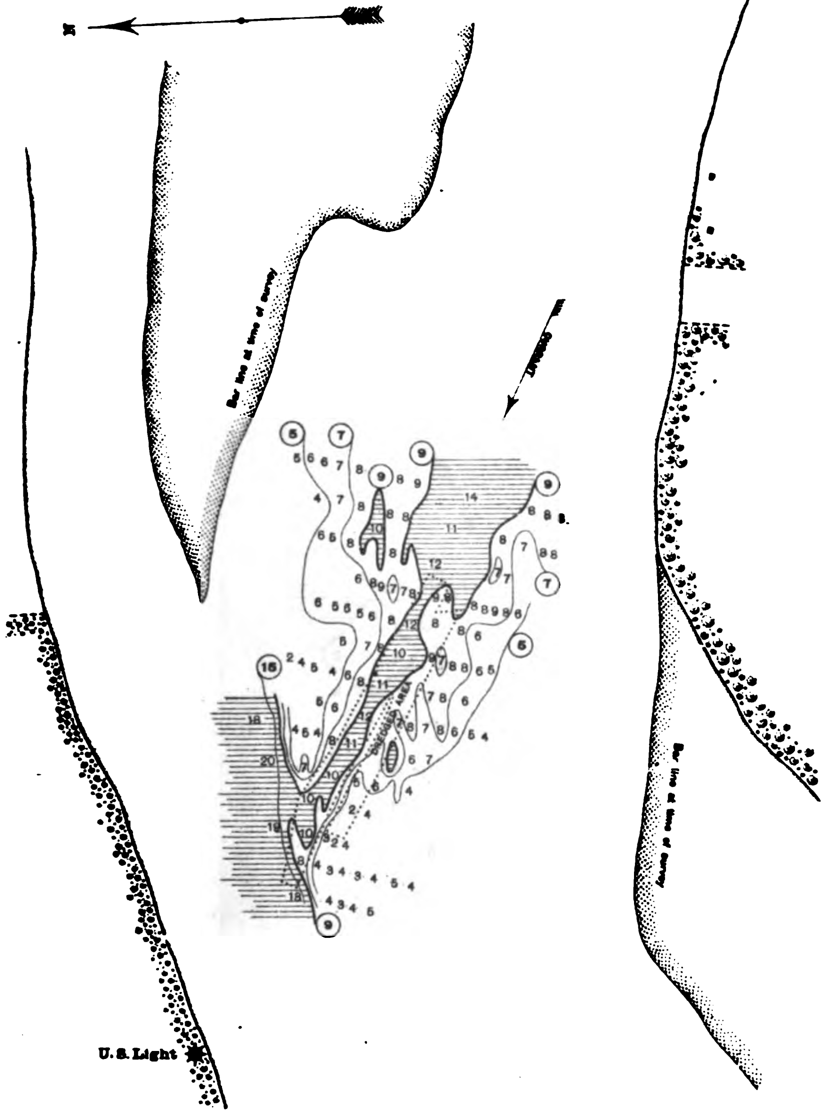
SCALE OF FEET.

1000 750 500 250 0 1000 2000

NOTE.—The numbers for soundings and contours are expressed in feet and indicate depths below mean low water on the Cottonwood Point, Mo., M.R.C. gage, which corresponds to a reading of 0.5 feet.

Gage at time of survey was 6.8 feet or 6.3 feet above mean low water.

Dotted areas indicate bars above mean low water.



THE NORRIS PETERS CO., PHOTO-LITHO., WASHINGTON, D. C.

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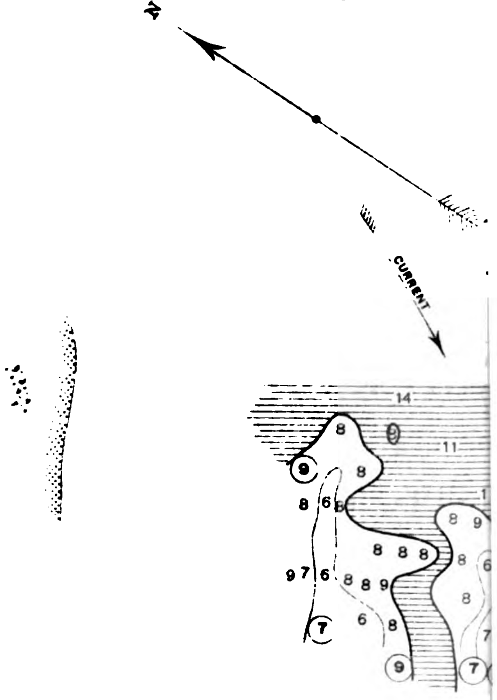
Dotted areas indic



THE NORRIS PETERS CO., PHOTO-LITHO., WASHINGTON, D. C.

PLATE 15.

MISSISSIPPI RIVER COMMISSION.

MAP OF

BOOTHS POINT, or ISLAND NO. 18 CROSSING,

Made under direction of

CAPTAIN G. P. HOWELL,

Corps of Engineers, U. S. A., Secretary.

Survey of October 20, 1902.

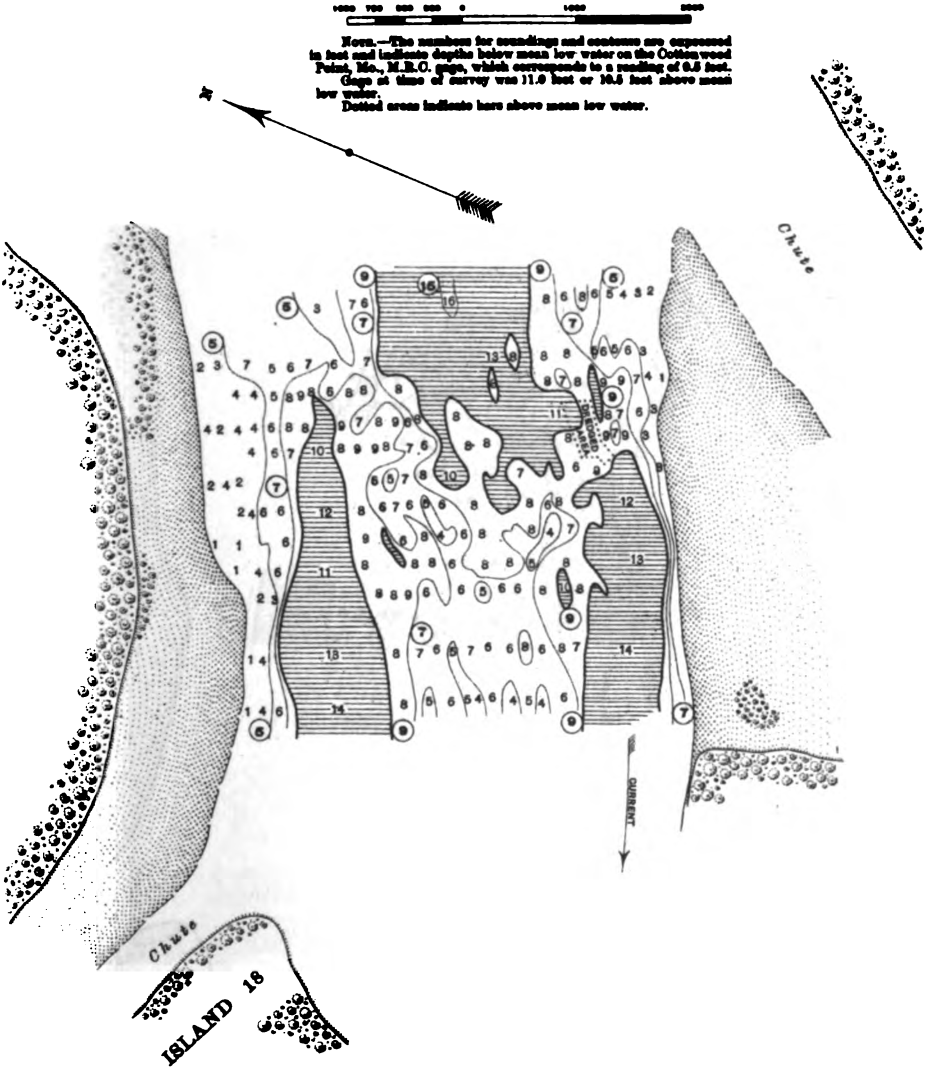
FOUR DAYS BEFORE DREDGING SECOND TIME.

SCALE OF FEET.

NOTE.—The numbers for soundings and contours are expressed in feet and indicate depths below mean low water on the Cottonwood Point, Mo., M.R.C. gage, which corresponds to a reading of 0.5 feet.

Gage at time of survey was 11.0 feet or 10.5 feet above mean low water.

Dotted areas indicate bars above mean low water.



MISSISSIPPI RIVER COMMISSION.

MAP OF

BOOTHS POINT, or ISLAND NO. 18 CROSSING,

Made under direction of

CAPTAIN G. P. HOWELL,

Corps of Engineers, U. S. A., Secretary.

Survey of November 6, 1902.

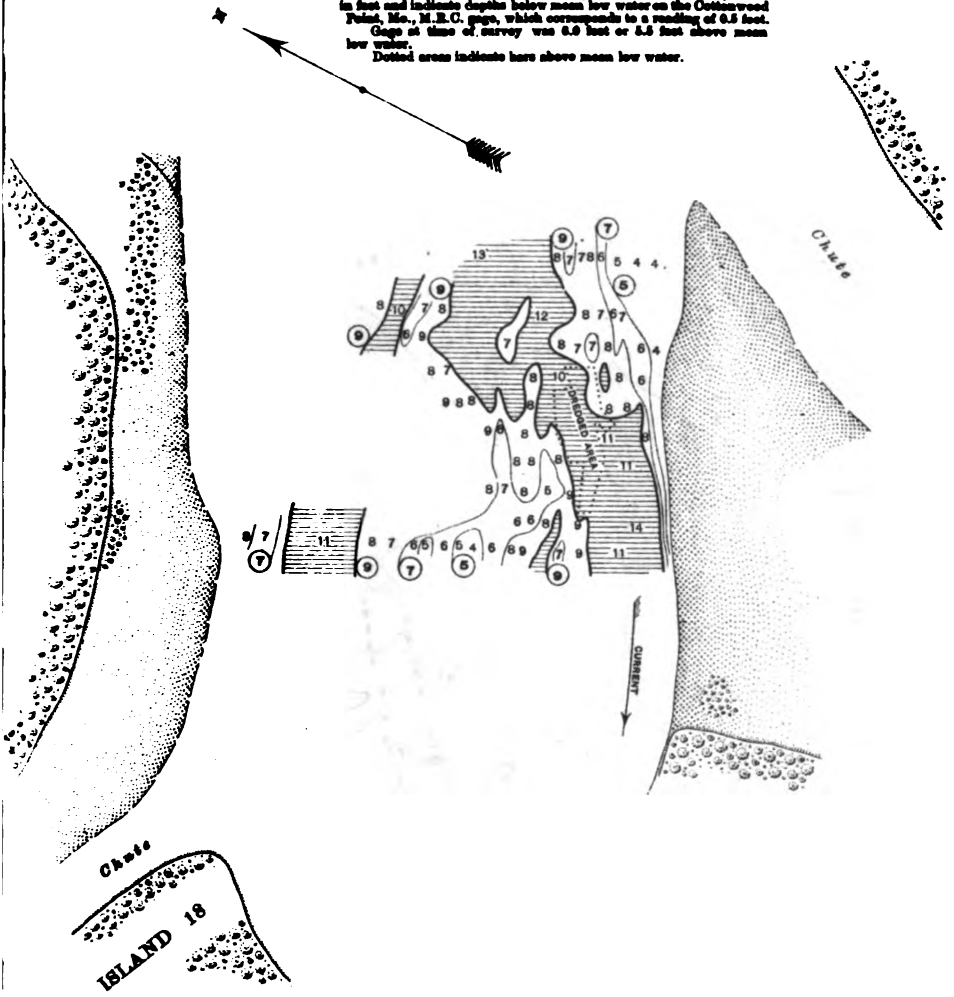
ONE DAY AFTER DREDGING SECOND TIME.

SCALE OF FEET.

NOTE.—The numbers for soundings and contours are expressed in feet and indicate depths below mean low water on the Cottonwood Point, Mo., M.R.C. gage, which corresponds to a reading of 0.5 feet.

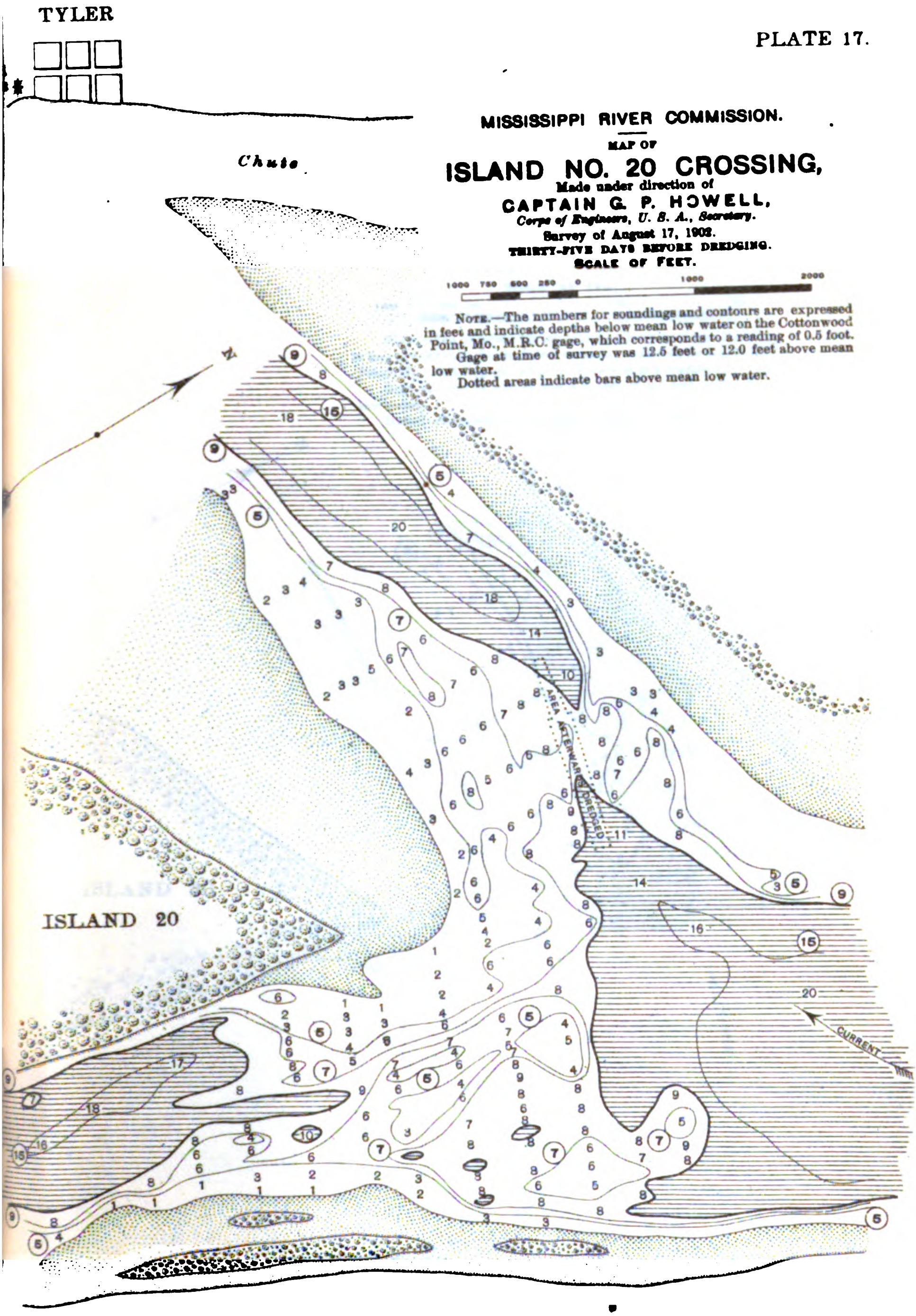
Gage at time of survey was 6.0 feet or 5.5 feet above mean low water.

Dotted areas indicate bars above mean low water.



The Norris Peters Co. Photo-Litho., Washington, D. C.

PLATE 17.



MISSISSIPPI RIVER COMMISSION.

MAP OF

ISLAND NO. 20 CROSSING,

Made under direction of

CAPTAIN G. P. HOWELL,

Corps of Engineers, U. S. A., Secretary.

Survey of August 17, 1902.

THIRTY-FIVE DAYS BEFORE DREDGING.

SCALE OF FEET.

NOTE.—The numbers for soundings and contours are expressed in feet and indicate depths below mean low water on the Cottonwood Point, Mo., M.R.C. gage, which corresponds to a reading of 0.5 foot. Gage at time of survey was 12.5 feet or 12.0 feet above mean low water.

Dotted areas indicate bars above mean low water.

THE NORRIS PETERS CO. PHOTO-LITHO., WASHINGTON, D. C.

PLATE 18.

MISSISSIPPI RIVER COMMISSION.

MAP OF

ISLAND NO. 20 CROSSING,

Made under direction of

CAPTAIN G. P. HOWELL,

Corps of Engineers, U. S. A., Secretary.

Survey of September 26, 1902.

ONE DAY AFTER DREDGING.

SCALE OF FEET.

1000 750 500 250 0 1000 2000

NOTE.—The numbers for soundings and contours are expressed in feet and indicate depths below mean low water on the Cottonwood Point, Mo., M.R.C. gage, which corresponds to a reading of 0.5 foot.

Gage at time of survey was 4.0 feet or 3.5 feet above mean low water.

Dotted areas indicate bars above mean low water.

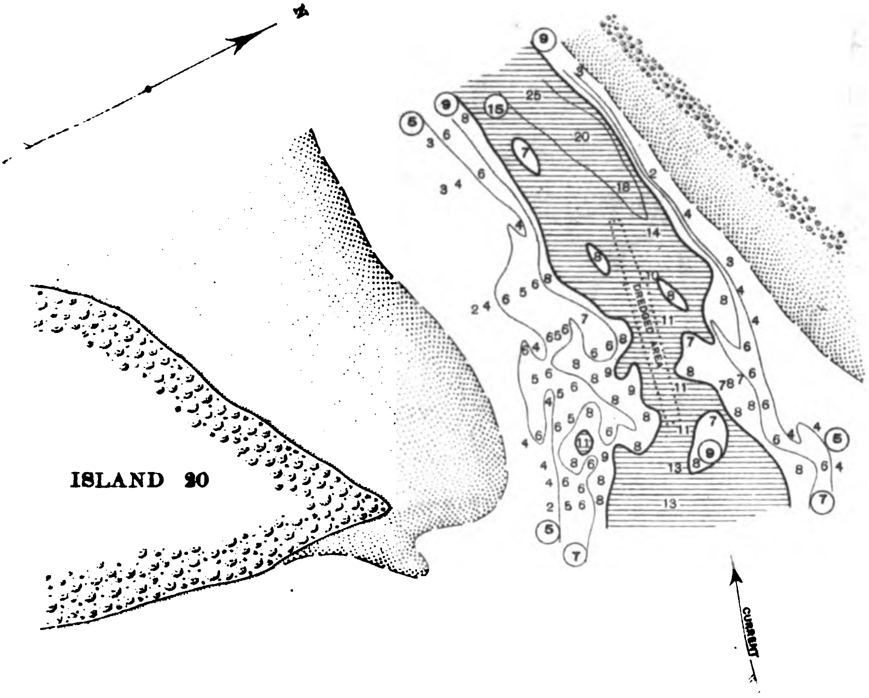
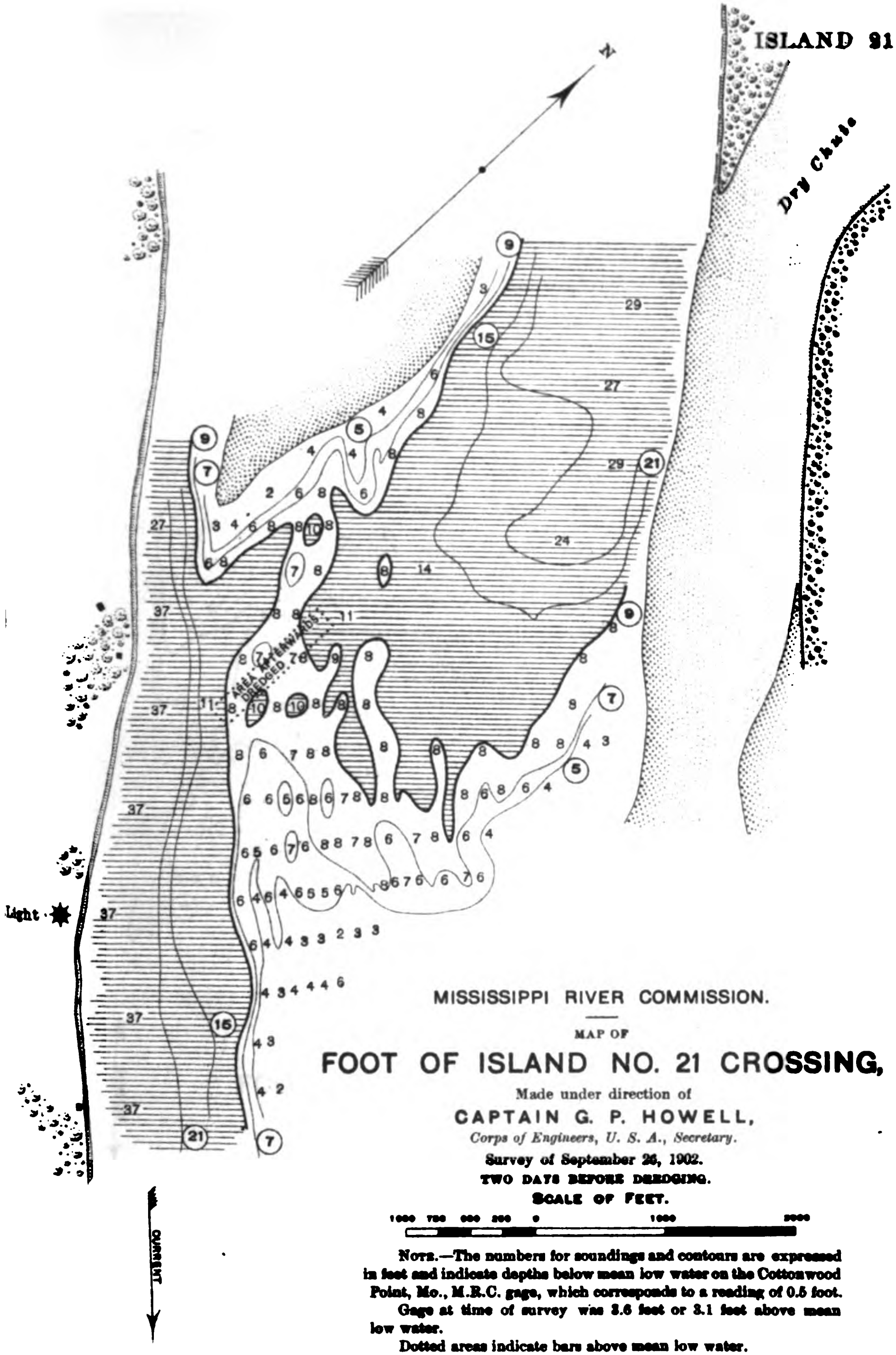


PLATE 19.



MISSISSIPPI RIVER COMMISSION.

MAP OF

FOOT OF ISLAND NO. 21 CROSSING,

Made under direction of

CAPTAIN G. P. HOWELL,

Corps of Engineers, U. S. A., Secretary.

Survey of September 26, 1902.

TWO DAYS BEFORE DREDGING.

SCALE OF FEET.

NOTE.—The numbers for soundings and contours are expressed in feet and indicate depths below mean low water on the Cottonwood Point, Mo., M.R.C. gage, which corresponds to a reading of 0.5 foot.

Gage at time of survey was 3.6 feet or 3.1 feet above mean low water.

Dotted areas indicate bars above mean low water.

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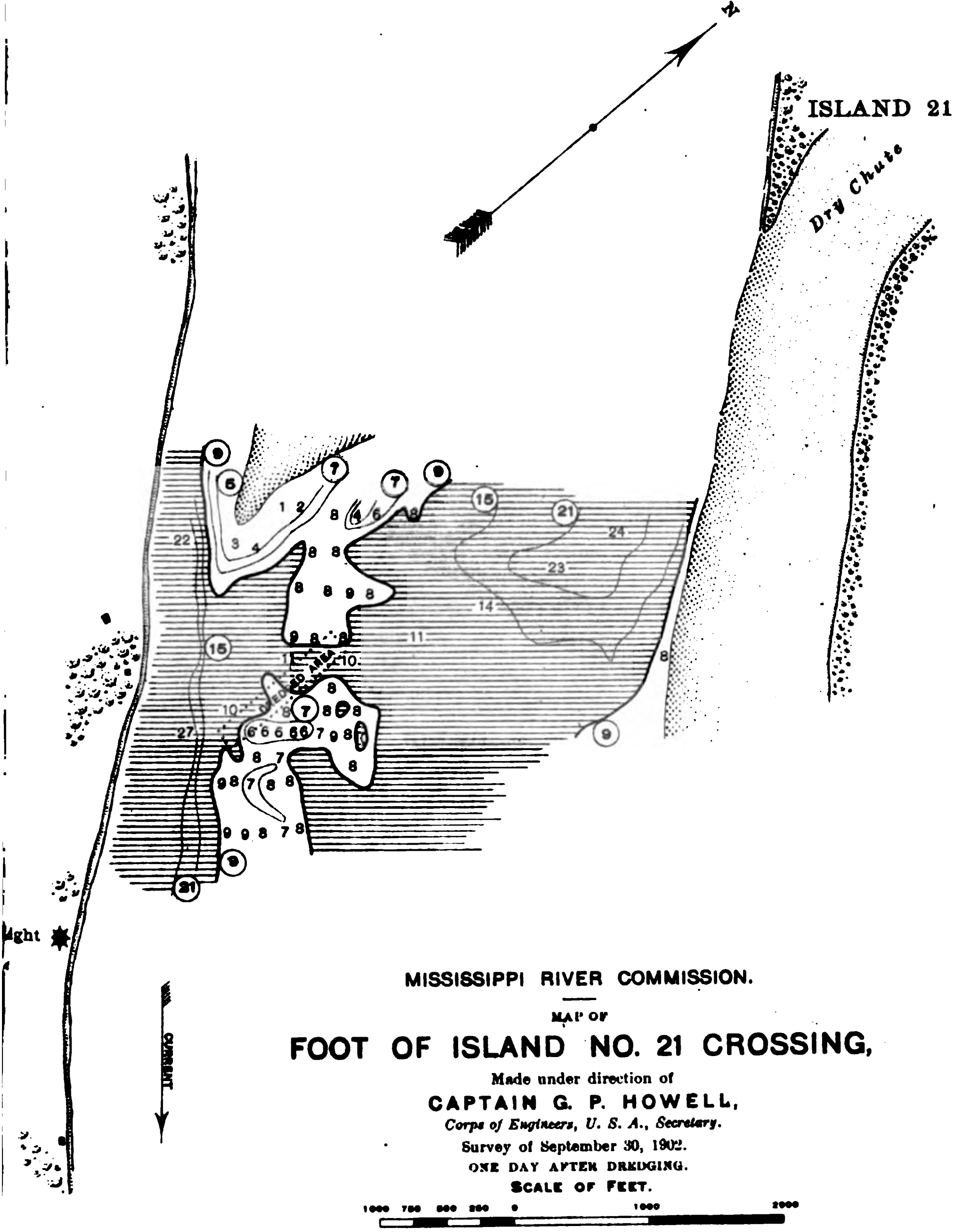
PLATE 20.



MISSISSIPPI RIVER COMMISSION.

MAP OF

FOOT OF ISLAND NO. 21 CROSSING,

Made under direction of

CAPTAIN G. P. HOWELL,

Corps of Engineers, U. S. A., Secretary.

Survey of September 30, 1902.

ONE DAY AFTER DREDGING.

SCALE OF FEET.

NOTE.—The numbers for soundings and contours are expressed in feet and indicate depths below mean low water on the Cottonwood Point, Mo., M.R.C. gage, which corresponds to a reading of 0.5 foot.

Gage at time of survey was 6.1 feet or 5.6 feet above mean low water.

Dotted areas indicate bars above mean low water.

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MISSISSIPPI RIVER COMMISSION.

MAP OF

LAST CHANCE CROSSING,

Made under direction of

CAPTAIN G. P. HOWELL,

Corps of Engineers, U. S. A., Secretary.

Survey of August 25, 1902.

ONE DAY BEFORE DREDGING.

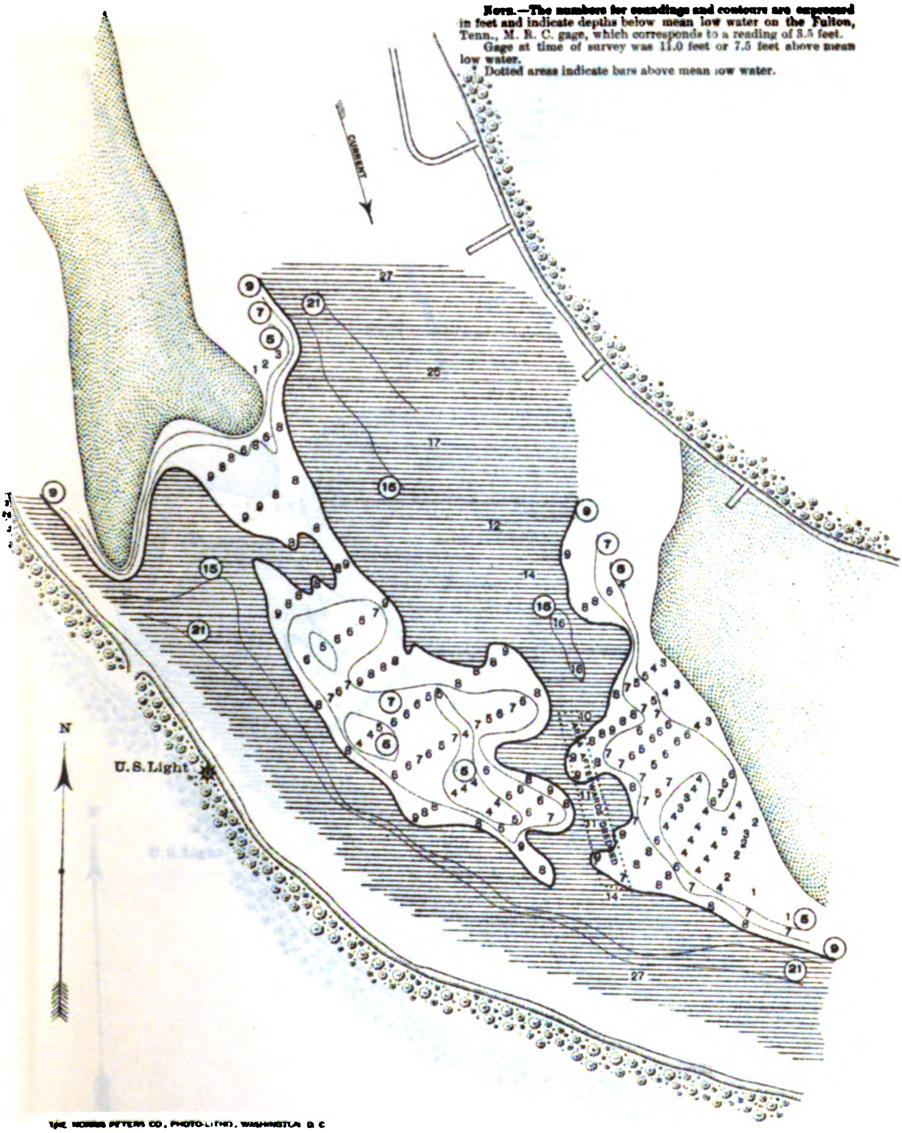
SCALE OF FEET.

1000 750 500 250 0 1000 2000

NOTE.—The numbers for soundings and contours are expressed in feet and indicate depths below mean low water on the Fulton, Tenn., M. R. C. gage, which corresponds to a reading of 3.5 feet.

Gage at time of survey was 11.0 feet or 7.5 feet above mean low water.

Dotted areas indicate bars above mean low water.



THE NORRIS PETERS CO., PHOTO-LITHO., WASHINGTON, D. C.

PLATE 22.

MISSISSIPPI RIVER COMMISSION.

MAP OF

LAST CHANCE CROSSING,

Made under direction of

CAPTAIN G. P. HOWELL,

Corps of Engineers, U. S. A., Secretary.

Survey of September 2, 1902.

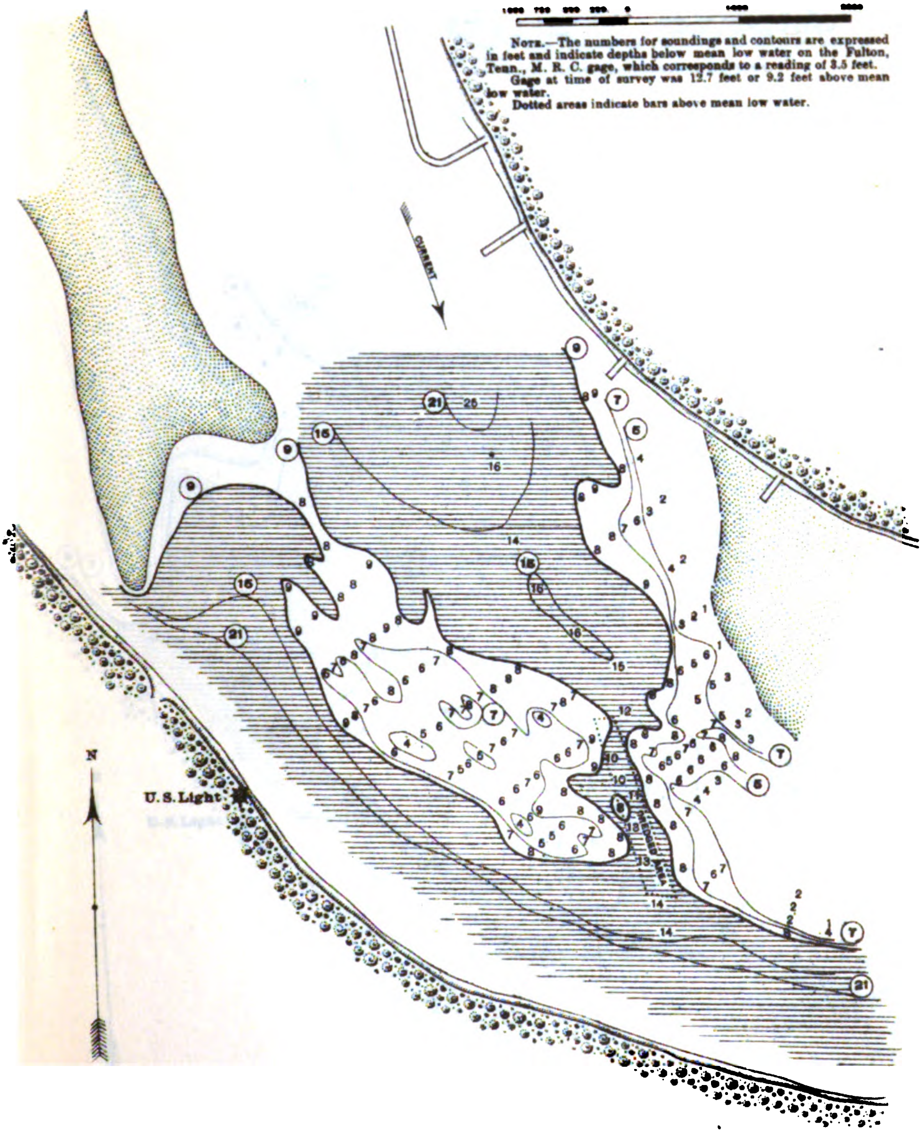
ONE DAY AFTER DREDGING.

SCALE OF FEET.

NOTE.—The numbers for soundings and contours are expressed in feet and indicate depths below mean low water on the Fulton, Tenn., M. R. C. gage, which corresponds to a reading of 3.5 feet.

Gage at time of survey was 12.7 feet or 9.2 feet above mean low water.

Dotted areas indicate bars above mean low water.



THE NORRIS PETERS CO., PHOTO-LITHO., WASHINGTON, D. C.

MISSISSIPPI RIVER COMMISSION.

MAP OF

LAST CHANCE CROSSING,

Made under direction of

CAPTAIN G. P. HOWELL,

Corps of Engineers, U. S. A., Secretary.

Survey of October 9, 1902.

THIRTEEN DAYS AFTER DREDGING—SECOND TIME.

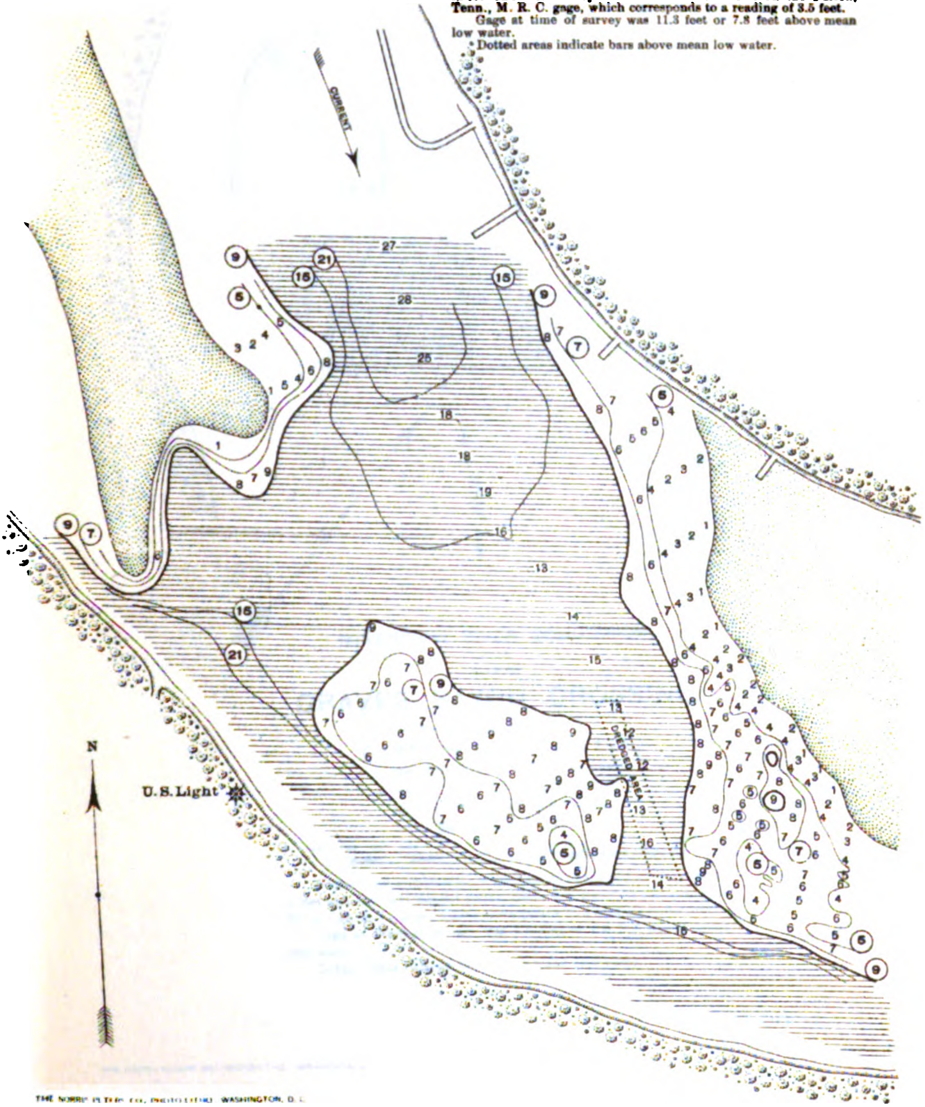
SCALE OF FEET.

1000 750 500 250 0 1000 2000

NOTE.—The numbers for soundings and contours are expressed in feet and indicate depths below mean low water on the Fulton, Tenn., M. R. C. gage, which corresponds to a reading of 3.5 feet.

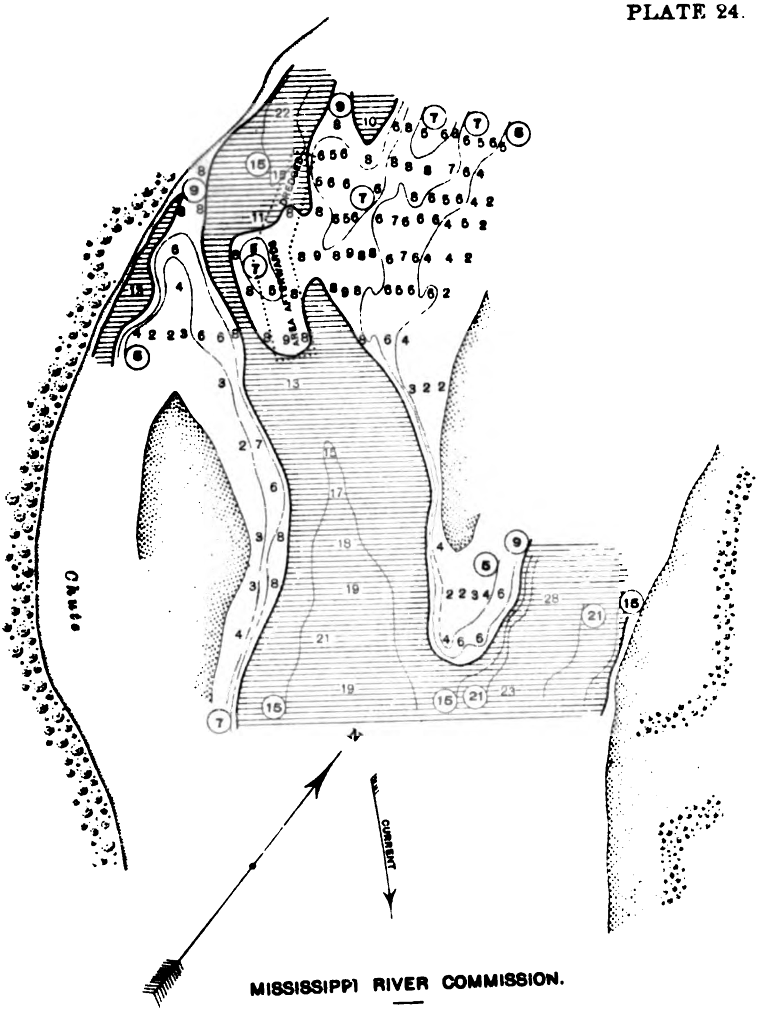
Gage at time of survey was 11.3 feet or 7.8 feet above mean low water.

Dotted areas indicate bars above mean low water.



THE NORRIS PETERS CO., PHOTO-LITHO., WASHINGTON, D. C.

PLATE 24.



MISSISSIPPI RIVER COMMISSION.

MAP OF

GRAVES BAYOU CROSSING,

Made under direction of

CAPTAIN G. P. HOWELL,

Corps of Engineers, U. S. A., Secretary.

Survey of November 11 and 12, 1902.

NINE DAYS BEFORE DREDGING.

SCALE OF FEET.

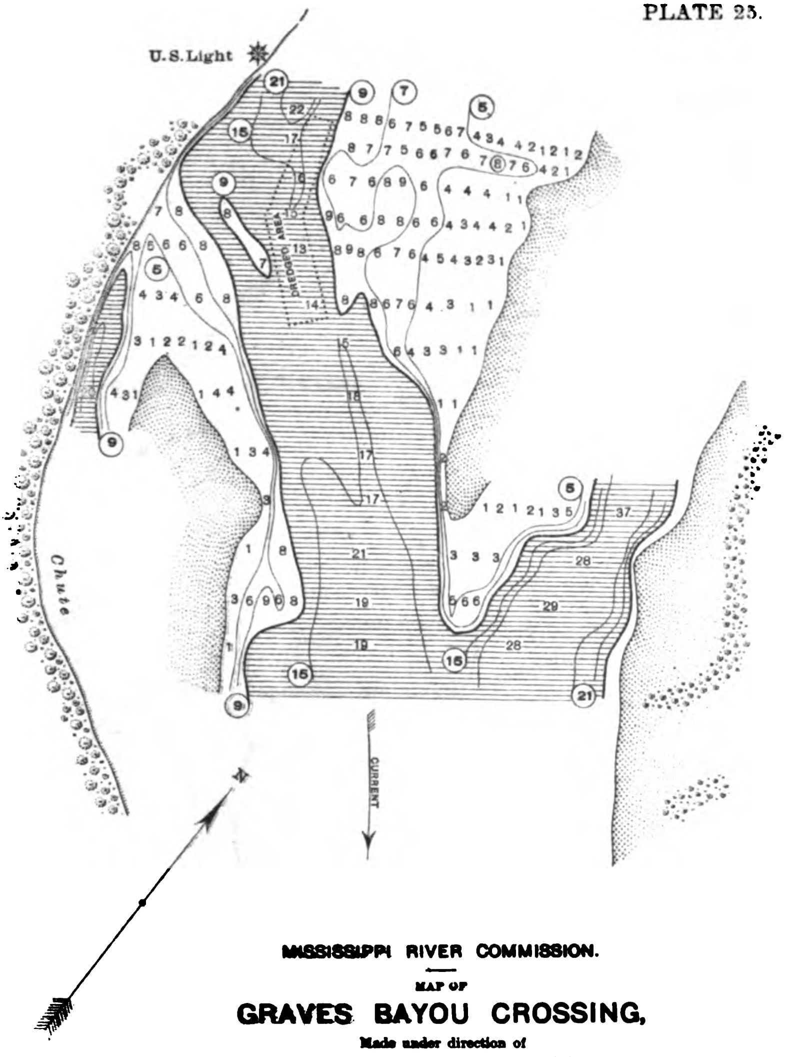
1000 750 500 250 0 1000 2000

NOTE.—The numbers for soundings and contours are expressed in feet and indicate depths below mean low water on the Memphis Tenn., M. R. C. gage, which corresponds to a reading of 0.9 foot.

Gage at time of survey was 3.9 feet or 3.0 feet above mean low water.

Dotted areas indicate bars above mean low water.

THE NORRIS PETERS CO. PHOTO-LITHO. WASHINGTON D. C.



MISSISSIPPI RIVER COMMISSION.

MAP OF

GRAVES BAYOU CROSSING,

Made under direction of

CAPTAIN G. P. HOWELL,

Corps of Engineers, U. S. A., Secretary.

Survey of December 1 and 2, 1902.

SIX DAYS AFTER DREDGING.

SCALE OF FEET.

1000 750 500 250 0 1000 2000

NOTE.—The numbers for soundings and contours are expressed in feet and indicate depths below mean low water on the Memphis, Tenn., M. R. C. gage, which corresponds to a reading of 0.9 foot.

Gage at time of survey was 8.4 and 9.4 feet or 7.5 and 8,5 feet above mean low water.

Dotted areas indicate bars above mean low water.

THE NORRIS PETERS CO. PHOTO-LITHO. WASHINGTON, D. C.

MISSISSIPPI RIVER COMMISSION.

MAP OF

PETERS UPPER CROSSING,

Made under direction of

CAPTAIN G. P. HOWELL,

Corps of Engineers, U. S. A., Secretary.

Survey of October 27, 1902.

NINE DAYS BEFORE DREDGING.

SCALE OF FEET.

1000 750 500 250 0 1000 2000

NOTE.—The numbers for soundings and contours are expressed in feet and indicate depths below mean low water on the Mhoons, Miss., M. R. C. gage, which corresponds to a reading of —4.0 feet.

Gage at time of survey was 10.2 feet or 14.2 feet above mean low water.

Dotted areas indicate bars above mean low water.

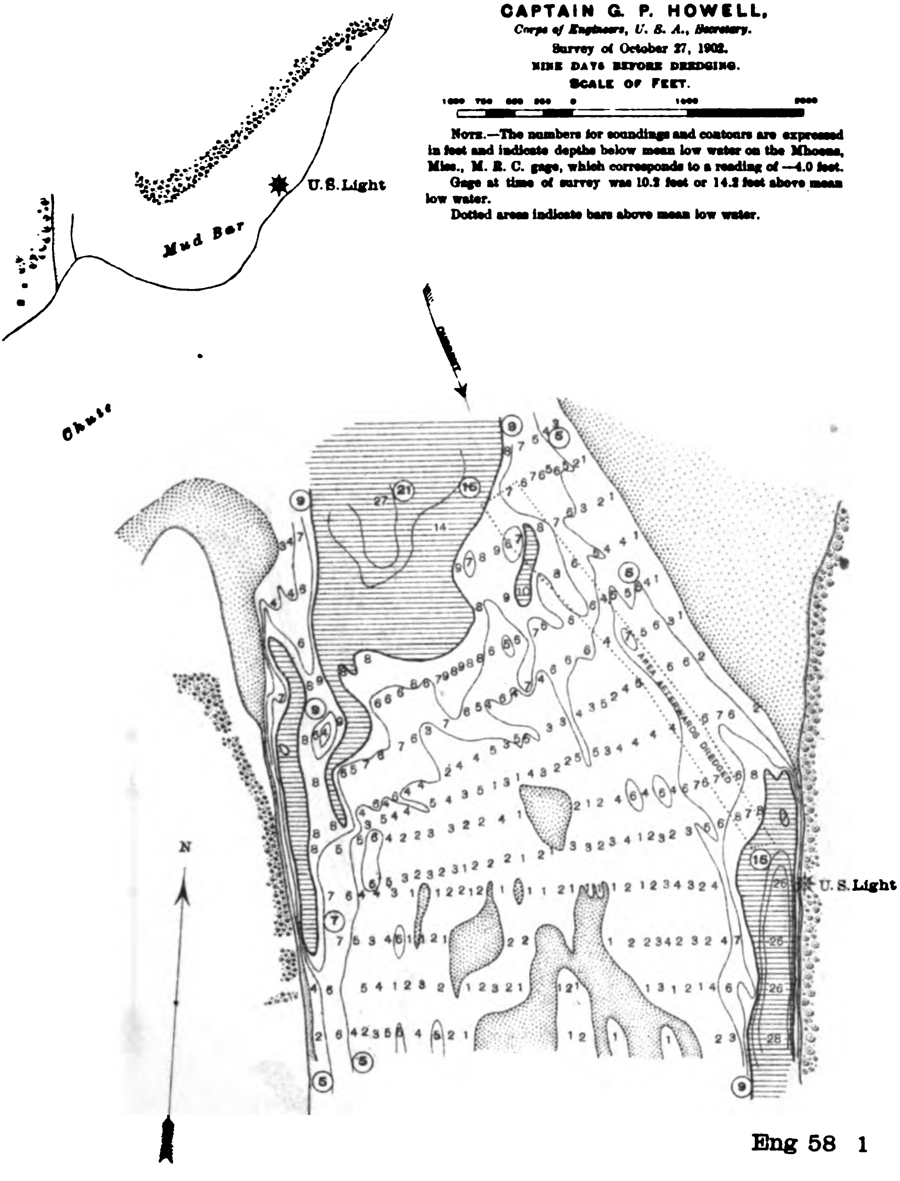


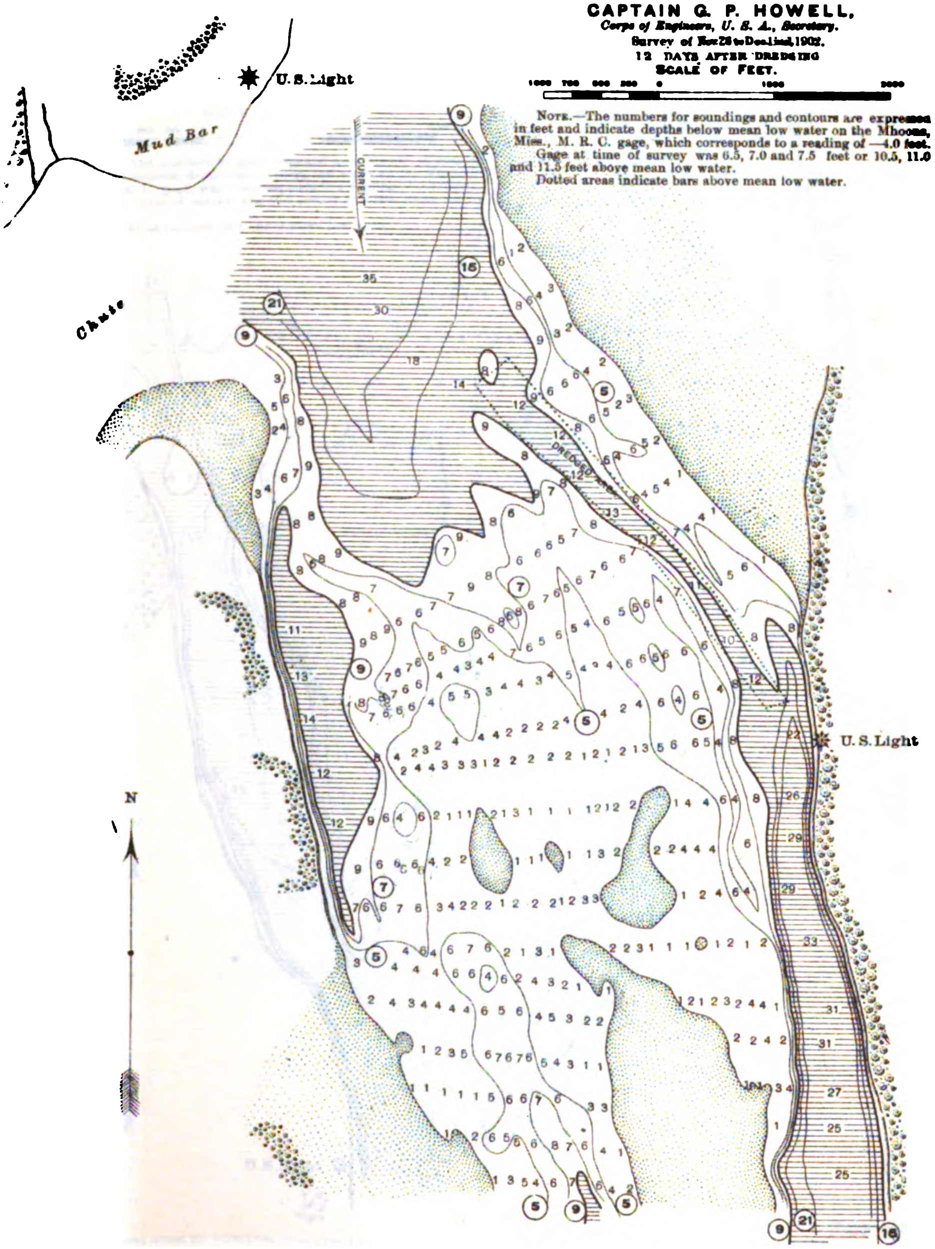
PLATE 27.

MISSISSIPPI RIVER COMMISSION.

MAP OF

PETERS UPPER CROSSING,

Made under direction of
CAPTAIN G. P. HOWELL,
Corps of Engineers, U. S. A., Secretary.
Survey of Nov. 28 to Dec. 1st, 1902.
12 DAYS AFTER DREDGING
SCALE OF FEET.



NOTE.—The numbers for soundings and contours are expressed in feet and indicate depths below mean low water on the Mhoons, Miss., M. R. C. gage, which corresponds to a reading of —4.0 feet.

Gage at time of survey was 6.5, 7.0 and 7.5 feet or 10.5, 11.0 and 11.5 feet above mean low water.

Dotted areas indicate bars above mean low water.

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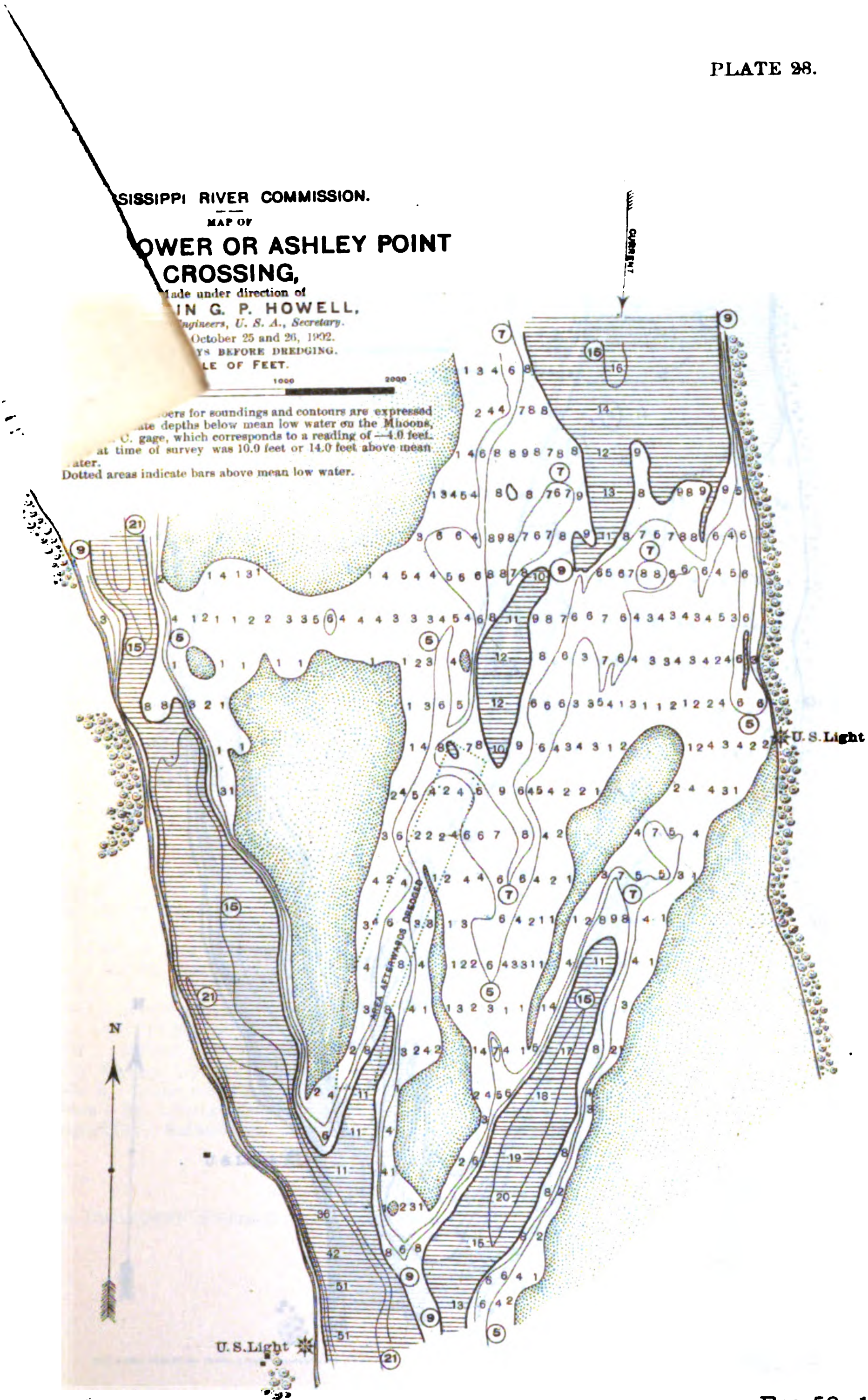

SISSIPPI RIVER COMMISSION.

MAP OF

OWER OR ASHLEY POINT CROSSING,

lade under direction of

IN G. P. HOWELL,

ngineers, U. S. A., Secretary.

October 25 and 26, 1902.

YS BEFORE DREDGING.

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bers for soundings and contours are expressed ate depths below mean low water on the Mhoons, C. gage, which corresponds to a reading of —4.0 feet. at time of survey was 10.0 feet or 14.0 feet above mean ater.

Dotted areas indicate bars above mean low water.

THE NORRIS PETERS CO. PHOTO-LITHO. WASHINGTON, D. C.

MISSISSIPPI RIVER COMMISSION.

MAP OF

PETERS LOWER OR ASHLEY POINT CROSSING,

Made under direction of

CAPTAIN G. P. HOWELL,

Corps of Engineers, U. S. A., Secretary.

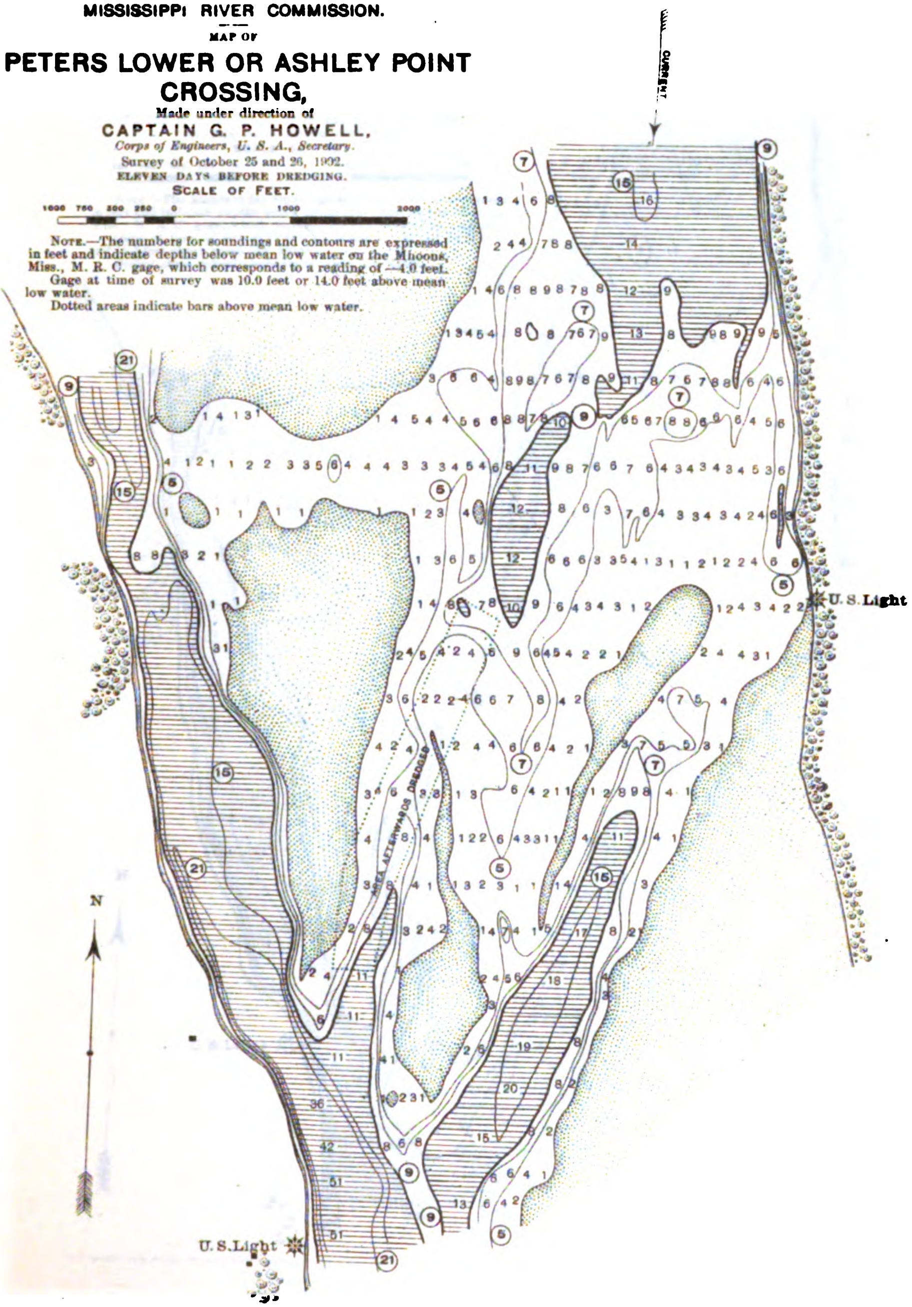
Survey of October 25 and 26, 1902.

ELEVEN DAYS BEFORE DREDGING.

SCALE OF FEET.

1000 750 500 250 0 1000 2000

NOTE.—The numbers for soundings and contours are expressed in feet and indicate depths below mean low water on the Mhoons, Miss., M. R. C. gage, which corresponds to a reading of —4.0 feet.
Gage at time of survey was 10.0 feet or 14.0 feet above mean low water.
Dotted areas indicate bars above mean low water.



THE NORRIS PETERS CO. PHOTO-LITHO. WASHINGTON, D. C.

MISSISSIPPI RIVER COMMISSION.

MAP OF

PETERS LOWER OR ASHLEY POINT CROSSING,

Made under direction of

CAPTAIN G. P. HOWELL,

Corps of Engineers, U. S. A., Secretary.

Survey of November 28, 29, 30 and December 1, 1902.

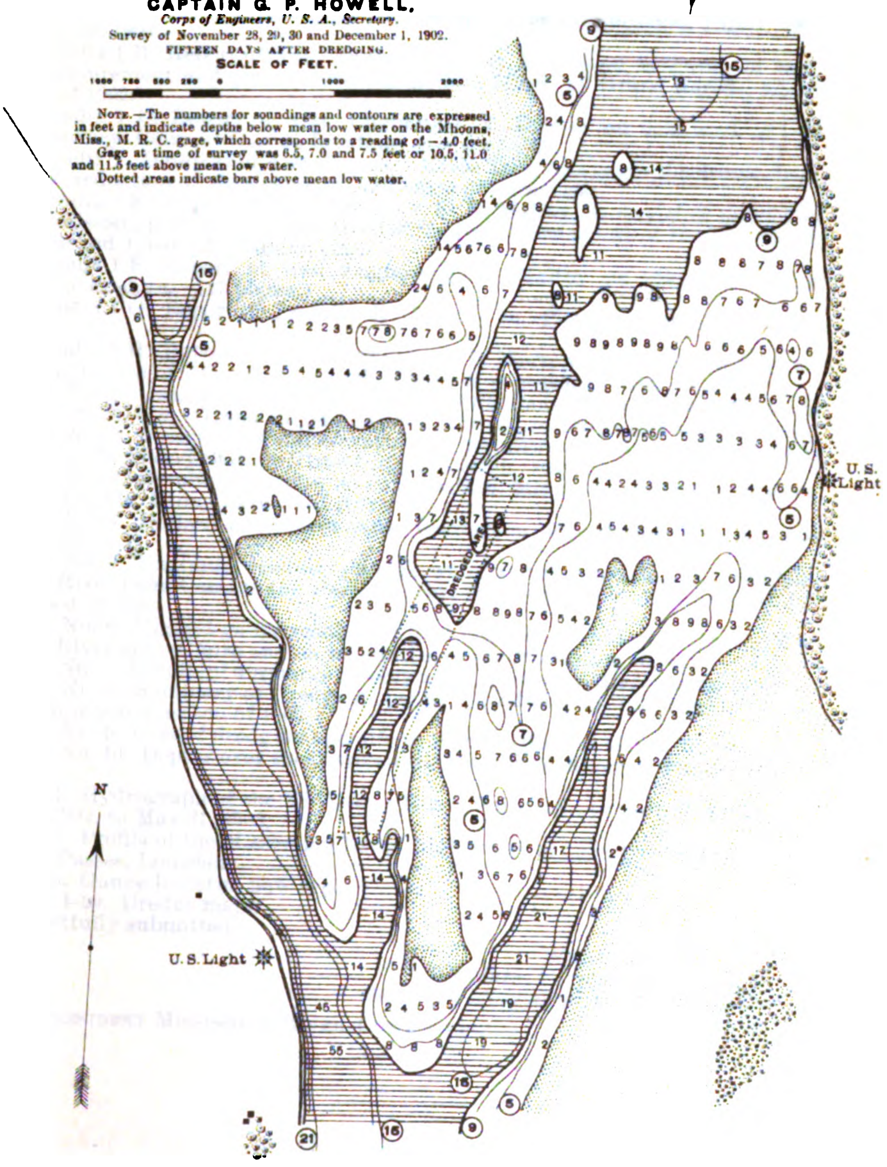
FIFTEEN DAYS AFTER DREDGING.

SCALE OF FEET.

NOTE.—The numbers for soundings and contours are expressed in feet and indicate depths below mean low water on the Mhoons, Miss., M. R. C. gage, which corresponds to a reading of – 4.0 feet.

Gage at time of survey was 6.5, 7.0 and 7.5 feet or 10.5, 11.0 and 11.5 feet above mean low water.

Dotted areas indicate bars above mean low water.



The discharge of the Mississippi was measured at St. Louis, July 18–19, 1902, in connection with this survey. The results will be found in Table No. 7.

For further details regarding this survey attention is respectfully invited to report of Asst. Engineer A. T. Morrow, Appendix 1 H.

The following papers accompany this report:

Money statements.

Consolidated statement of appropriations and allotments.

Abstracts of contracts in force.

Commercial statistics.

Statement of charts issued and sold.

Appendix 1 A. Laws affecting the Mississippi River Commission, July 1, 1902, to June 30, 1903.

Appendix 1 B. Report of Asst. Engineer Geo. H. French on fieldwork of tapeline measurement and precise leveling, Aitkin, Minn., to Grand Rapids, Minn., season of 1902.

Appendix 1 C. Report of Asst. Engineer A. T. Morrow on field work of low-water survey, Cairo to Corona Landing, season of 1902.

Appendix 1. D Report of Asst. Engineer Kivas Tully on gauges, discharge observations, reduction of physical data, and office publications.

Appendix 1 E. Report of Asst. Engineer F. B. Maltby on dredging operations on the Mississippi River between Head of the Passes and mouth of the Ohio River, and care and repair of dredging plant.

Appendix 1 F. Report of Asst. Engineer F. B. Maltby on efficiency tests of hydraulic dredges. (47 plates.)

Appendix 1 G. Report of Prof. W. B. Gregory on efficiency tests of hydraulic dredges.

Appendix 1 H. Report of Asst. Engineer A. T. Morrow on deep waterway survey from mouth of Illinois River to St. Louis, Mo., season of 1902.

Table No. 1. Geographical positions north of St. Paul, Minn., Aitkin, Minn., to Blackberry Station (Grand Rapids) Minn.; referred to Cairo astronomical post.

Table No. 2. Descriptions and elevations of permanent survey marks, Aitkin, Minn., to Blackberry Station (Grand Rapids) Minn., season of 1902.

Table No. 3. Results of precise leveling, Aitkin, Minn., to Blackberry Station (Grand Rapids, Minn.), season of 1902.

Table No. 4. Highest and lowest gauge readings in 1902, Mississippi River and tributaries.

Table No. 5. Maximum readings on high-water and regular gauges on the Mississippi River from Cairo to the Passes during the flood of 1903, also comparison with flood of 1897.

Table No. 6. Highest gauge readings in 1903 (to June 30) at stations on the Mississippi River above Cairo and on tributaries of the Mississippi River.

Table No. 7. Results of discharge observations, Mississippi River and tributaries.

Table No. 8. Summary of dredging operations, Mississippi River below Cairo, during low-water season of 1902.

Table No. 9. Cost of dredging operations, April 1, 1902, to March 31, 1903.

Table No. 10. Depths over shoal crossings, Mississippi River, low-water season of 1902.

Plate 1. Hydrograph of the Mississippi River, Cairo, Ill., to Fort Jackson, La., June 1, 1902, to May 31, 1903.

Plate 2. Profile of the Mississippi River, high water of 1903, from Cairo, Ill., to Head of Passes, Louisiana.

Plate 3. Gauge bulletin, new type.

Plates 4–29. Dredge maps.

Respectfully submitted.

Wm. B. Ladue,
Captain, Corps of Engineers,
Secretary Mississippi River Commission.

The President Mississippi River Commission.

Money statements.

[Appropr'ation for improving Mississippi River.]

July 1, 1902, balance unexpended		$124,413.66
Amount allotted from appropriation by river and harbor act approved June 13, 1902	$411,000.00	
Amount allotted from appropriation by sundry civil act approved March 3, 1903	50,000.00	
Miscellaneous receipts for engineer property transferred by authority of the Secretary of War under the provisions of section 5 of the river and harbor act of June 13, 1902	250.00	
		461,250.00
		585,663.66
June 30, 1903, amount expended during fiscal year		335,852.73
July 1, 1903, balance unexpended		249,810.93
July 1, 1903, outstanding liabilities	$29,958.24	
July 1, 1903, amount covered by uncompleted contracts	43,549.70	
		73,507.94
July 1, 1903, balance available		176,302.99

[Appropriation for gauging the waters of the Lower Mississippi and its tributaries.[a]]

July 1, 1902, balance unexpended	$320.00
Amount allotted by Chief of Engineers, July 23, 1902, from permanent indefinite appropriation made by section 6 of river and harbor act of August 11, 1888, as amended by section 9 of river and harbor act of June 13, 1902	9,100.00
	9,420.00
June 30, 1903, amount expended during fiscal year	7,878.64
July 1, 1903, balance unexpended	1,541.36
July 1, 1903, outstanding liabilities	654.47
July 1, 1903, balance reverting to Treasury	886.89
Amount that can be profitably expended in fiscal year ending June 30, 1905, in addition to the balance unexpended July 1, 1903	9,600.00

Itemized statement of expenditures during the fiscal year ending June 30, 1903, submitted in compliance with requirement of section 6 of river and harbor act of August 11, 1888.

Observations:		
Pay of permanent gauge observers		$3,540.00
Inspections and repairs:		
Inspection of gauges on Mississippi River by junior engineer and party on steamer	$1,315.83	
Inspection of gauges on tributaries	171.98	
Repairs to gauges and bulletins	1,162.18	
		2,649.99
Office expenses and contingencies:		
Pay of assistant and junior engineers	1,355.26	
Pay of clerks	158.33	
Stationery, printing, etc	175.06	
		1,688.65
		7,878.64

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[a] The custody and care of the gauges maintained under this appropriation were assumed by the Mississippi River Commission February 11, 1901, on which date they were transferred to the secretary, under authority of Secretary of War, dated January 25, 1901.

[Appropriation for waterway from Lockport, Ill., to St. Louis, Mo.]

Amount appropriated by river and harbor act approved June 13, 1902	$25,000.00
June 30, 1903, amount expended during fiscal year	7,472.48
July 1, 1903, balance unexpended	17,527.52
July 1, 1903, balance available	17,527.52

Consolidated statement of appropriations and allotments.

[Appropriation for gaging the waters of the Lower Mississippi and its tributaries.]

Allotments from general appropriations for examinations, surveys, and contingencies of rivers and harbors by acts of—	
March 3, 1871	$5,000.00
June 10, 1872	5,000.00
March 3, 1873	5,000.00
June 23, 1874	5,000.00
March 3, 1875	5,000.00
Specific appropriations by river and harbor acts of—	
August 14, 1876	5,000.00
June 18, 1878	5,000.00
March 3, 1879	5,000.00
June 14, 1880	5,000.00
March 3, 1881	5,000.00
August 2, 1882	5,000.00
Deficiency act of March 12, 1884	2,100.00
Specific appropriations by river and harbor acts of—	
July 5, 1884	5,000.00
August 5, 1886	5,000.00
Allotted from specific appropriation by river and harbor act of August 11, 1888	8,700.00
Deficiency act of October 19, 1888	3,600.00
Allotments from permanent indefinite appropriation made by section 6 of river and harbor act of August 11, 1888, for fiscal years, viz:	
1890	9,000.00
1891 (less $3,518.34 withheld in United States Treasury under ruling that only $6,000 can be expended each fiscal year)	5,181.66
1892	5,100.00
1893	5,500.00
1894	5,500.00
1895	5,500.00
1896	5,500.00
1897	5,500.00
1898	5,500.00
1899	6,000.00
1900	5,500.00
1901	6,000.00
1902	6,000.00
Allotment from permanent indefinite appropriation made by section 6 of river and harbor act of August 11, 1888, as amended by section 9 of river and harbor act of June 13, 1902	9,100.00
Total	164,281.66

EXPENDED.

	To June 30, 1902.	During year ending June 30, 1903.	Total.
Expenditures	$147,389.79	$7,878.64	$155,268.43
Unexpended balances reverted to Treasury	7,471.87	886.89	8,358.76
Total	154,861.66	8,765.53	163,627.19
Unexpended balance June 30, 1903			654.47
Total appropriated, etc			164,281.66

[Appropriation for waterway from Lockport, Ill., to St. Louis, Mo.]

Act of June 13, 1902 (river and harbor)	$25,000.00
Expenditures to June 30, 1903	7,472.48
Unexpended balance June 30, 1903	17,527.52
Total appropriated, etc	25,000.00

Abstract of contracts entered into by Capt. Wm. B. Ladue, Corps of Engineers, in force June 30, 1903.—Improving Mississippi River, Mississippi River Commission, secretary's office.

Contract for—	Contractor.	Rate per bushel.	Date of contract.	Date of approval.	Date of beginning work.	Date of expiration.
300,000 bushels coal.	The Monongahela River Consolidated Coal and Coke Co.	*Cents.* 18	May 7, 1903	June 6, 1903	June 6, 1903	Dec. 1, 1903

COMMERCIAL STATISTICS FOR CALENDAR YEAR 1902.

TABLE NO. 1.

Tonnage between—	Passengers.	Receipts and shipments in tons.				
		Grain and its products.	Cotton.	Cotton seed.	Live stock.	Coal and coke.
St. Louis and Cairo	102,567	194,175	3,144	....	46,458	110,090
Cairo and Memphis	63,135	91,593	50,315	23,813	536	1,289,830
Memphis and Vicksburg	149,467	119,197	55,075	37,175	14,719	1,248,046
Vicksburg and New Orleans	106,388	102,544	64,774	80,973	4,814	1,220,057

Tonnage between—	Receipts and shipments in tons.					
	Lumber.	Logs.	Iron, steel, and metals.	Groceries and provisions.	Miscellaneous and unclassified.	Total.
St. Louis and Cairo	130,595	77,089	3,873	105,171	280,859	951,454
Cairo and Memphis	287,294	386,977	247,565	15,317	155,121	2,548,331
Memphis and Vicksburg	124,763	175,409	51,052	47,289	67,301	1,940,026
Vicksburg and New Orleans	49,350	52,433	51,714	193,099	339,500	2,159,258

Each stretch is treated as a separate river, and tonnage carried between ports on different stretches will appear in the statistics of all intervening stretches. Consequently the sum of the tonnage carried in the four stretches does not give the total traffic on the river.

TABLE NO. 2.—*Receipts and shipments at principal ports.*

Ports of—	Passengers carried in and out of port.	Receipts and shipments in tons.				
		Grain and its products.	Cotton.	Cotton seed.	Live stock.	Coal and coke.
St. Louis, Mo	88,407	171,546	1,349	....	25,621	69,965
Memphis, Tenn	99,987	13,030	31,060	36,549	8,181	132,180
Vicksburg, Miss.[a]	60,593	14,351	18,593	14,838	2,111	35,180
New Orleans, La.[b]	27,802	744,441	631,233	375,554	20,819	1,152,192

TABLE NO. 2.—*Receipts and shipments at principal ports*—Continued.

Ports of—	Receipts and shipments in tons.					
	Lumber.	Logs.	Iron, steel, and metals.	Groceries and provisions.	Miscellaneous and unclassified.	Total.
St. Louis, Mo	107,659	54,663	2,820	46,845	161,214	641,182
Memphis, Tenn	30,227	156,573	129,852	13,529	67,259	618,390
Vicksburg, Miss.[a]	29,335	59,714	1,550	22,009	35,678	233,359
New Orleans, La.[b]	211,204	49,570	210,527	573,273	1,085,068	5,053,851

[a] The traffic on the Yazoo River and its tributaries not included.
[b] Includes exports and imports and the domestic coastwise traffic as far as reported

TABLE NO. 3.—*Seagoing traffic at New Orleans, La.*

Arrivals and departures:	
Number	2,676
Tonnage	4,759,097
Receipts and shipments:	Tons.
Grain and its products	650,112
Cotton	571,622
Cotton seed and its products	320,895
Live stock	18,579
Lumber	178,890
Iron, steel, and metals	158,913
Groceries and provisions	388,201
Miscellaneous and unclassified	810,588
Total	3,097,800

TABLE NO. 4.—*Ferry traffic.*

Location of ferries and transfers.	Passengers.	Receipts and shipments in tons.				
		Grain and its products.	Cotton.	Cotton seed.	Live stock.	Coal and coke.
St. Louis, Mo	1,875,675	....	....	....	....	604,282
Cape Girardeau, Mo	12,412	2,162	2,520	224	62	58,638
Grays Point, Mo., to Thebes and Gale, Ill	5,282	56,946	29,503	856	546	8,511
Cairo, Ill	29,258	3,903	....	....	356	25
Belmont, Mo., and Columbus, Ky	34,578	....	....	....	....	....
Memphis, Tenn	111,500	240,425	106,500	75,700	16,910	320,025
Helena, Ark	37,463	8,062	10,429	3,050	15	4,294
Arkansas City, Ark	1,200	....	....	....	....	....
Vicksburg, Miss	74,218	36,640	48,277	9,841	9,400	73,045
Natchez, Miss	51,261	1,000	8,909	....	1,051	4,740
Bayou Sara, La	128	650	....	500	250	....
Baton Rouge, La	54,000	....	....	....	....	....
Donaldsonville, La	179,215	....	....	....	....	....
New Orleans, La	1,833,375	76,258	115,692	75,209	11,101	211,059

Location of ferries and transfers.	Receipts and shipments in tons.					
	Lumber.	Logs.	Iron, steel, and metals.	Groceries and provisions.	Miscellaneous and unclassified.	Total.
St. Louis, Mo	445,000	....	20,000	....	4,706,635	5,775,917
Cape Girardeau, Mo	180,452	25	52,354	4,429	17,719	318,585
Grays Point, Mo., to Thebes and Gale, Ill	284,248	....	56,492	....	144,158	522,119
Cairo, Ill	220	150	155	3,940	1,064,062	1,072,811
Belmont, Mo., and Columbus, Ky	....	....	....	....	56,807	56,807
Memphis, Tenn	250,200	88,000	128,000	63,000	800,000	1,588,760
Helena, Ark	23,792	....	337	5,359	15,089	70,427
Arkansas City, Ark	....	....	....	....	....	....
Vicksburg, Miss	184,658	....	24,787	3,482	78,332	468,462
Natchez, Miss	119	....	202	1,000	32,763	49,784
Bayou Sara, La	200	....	....	500	....	2,100
Baton Rouge, La	....	....	....	....	1,327	1,327
Donaldsonville, La	....	....	....	....	....	....
New Orleans, La	159,702	....	82,062	594,584	701,522	2,027,209

Statement of maps and charts issued and sold from July 1, 1902, to June 30, 1903.

Description.	Free.	Sold.	Total.
Upper alluvial valley map	48	31	79
Lower alluvial valley map	216	344	560
Inch-to-mile map	741	660	1,401
Detail chart, 1:20000 scale	2,304	616	2,920
Detail chart, 1:10000 scale	2,180	....	2,180
Detail chart, 1:10000 scale (harbor of New Orleans)	12	52	64
District map of lower Mississippi River	4	6	10
Total	5,505	1,709	7,214

Proceeds deposited with the assistant treasurer of the United States at St. Louis, Mo., $258.36.

APPENDIX 1 A.

LAWS AFFECTING THE MISSISSIPPI RIVER COMMISSION, JULY 1, 1892, TO JUNE 30, 1903.

[PUBLIC—No. 157.]

AN ACT making appropriations for sundry civil expenses of the Government for the fiscal year ending June 30, 1904, and for other purposes.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the following sums be, and the same are hereby, appropriated for the objects hereinafter expressed for the fiscal year ending June thirtieth, nineteen hundred and four, namely:

* * * * * * *

UNDER THE WAR DEPARTMENT.

* * * * * * *

UNDER THE MISSISSIPPI RIVER COMMISSION.

Improving Mississippi River: For continuing improvement of Mississippi River from Head of Passes to the mouth of the Ohio River, including salaries and clerical, office, traveling, and miscellaneous expenses of the Mississippi River Commission, two million dollars.

* * * * * * *

Approved, March 3, 1903.

APPENDIX 1 B.

REPORT OF ASSISTANT ENGINEER GEORGE H. FRENCH, ON FIELD WORK OF TAPE-LINE MEASUREMENT AND PRECISE LEVELING BETWEEN AITKIN, MINN., AND BLACKBERRY STATION (GRAND RAPIDS), MINN., SEASON OF 1902.

ST. LOUIS, MO., *January 15, 1903.*

CAPTAIN: I have the honor to submit the following report on work done by the tapeline and precise level party under my charge during the field season of 1902.

Acting under your orders I left St. Louis, Mo., on March 17, and proceeded to Aitkin, Minn., for the purpose of getting the camp outfit and party ready to begin operations at that place.

On March 25 field work was begun at Aitkin with the party organized as follows: George H. French, in charge: E. L. Harman, precise levels; George H. Wolbrecht, observer angles and azimuth; E. E. Whitehead, computer: 4 recorders, 1 foreman, 1 cook, 18 surveymen, 2 waiters, 5 teams complete with teamsters. The party numbered 30 men.

The tapeline work was started from a point on the west bank of the river located by triangulation from the line ◬ Seeley to ◬ Stewart as a base, being the upper limit of secondary triangulation of 1898. The work followed along the State road on the west side of the river to B. M. Blackberry, 6½ miles east of Grand Rapids Minn., the end of tapeline work from Bemidji completed season 1900.

Precise levels were continued from the upper limit of the work at Aitkin, Minn., season 1898, following the State road to B. M. Blackberry, lower limit of work season 1900.

Permanent marks were established by precise level party from 2½ to 3 miles apart by planting the regulation tile and pipe. These points were located by tapeline party where practicable. Angle points of tapeline were marked with a post 10 to 12 inches diameter, 5½ feet long, planted firmly in the ground, top of post 42 inches above ground. A point in center marks angle point and point of measurement. Descriptions were made of permanent marks and angle points and trees blazed with △ with bearing and distance taken.

Tapeline measurements were made over each course with 200-foot steel tape supported every 50 feet, 16 pounds tension being applied by a spring balance. The balance was tested twice a day while in use. Temperature was determined by one thermometer held near the tape at its center. Ends of tape lengths were marked by black pins stuck in soft pine blocks fastened in tripod heads. Differences of elevation of top of blocks in tripod heads were determined by ordinary level checking up on precise levels to determine elevation above sea level. Angles of deflection were measured with theodolite T. & S. No. 1, four sets of angles being taken at each angle point. Azimuth observations were taken in the vicinity of Sandy Lake and mouth of Swan River.

Effort was made to bring the discrepancy between two measurements of a line within the prescribed limit of 1 in 100,000, but in some of the lines through swamps, where nothing was stable, the discrepancy exceeded the limit and remeasuring failed to bring good results. The discrepancy in the majority of lines, however, was far within the limit.

Work was completed to B. M. Blackberry June 27, when the party was disbanded and property returned to Aitkin, where it was turned over to the watchman.

The party was employed ninety-four days; during that time there were twelve Sundays and one holiday, five days for moving camp, two rainy days, and three days constructing new road, leaving a total of seventy-one working days. During this time 55.15 miles main line and 2.02 miles of side line were taped in duplicate.

The average discrepancy between measurements was 1 in 441,000. The observed azimuth at Sandy Lake was 9.02 seconds larger than that carried from Aitkin, and the observed azimuth at mouth of Swan River was 6.84 seconds smaller than that carried from Sandy Lake.

Respectfully submitted.

Geo. H. French, *Assistant Engineer.*

Capt. G. P. Howell,
Corps of Engineers, U. S. Army,
Secretary Mississippi River Commission.

TABLE No.1—*Geographical positions north of St. Paul, Minn.; Aitkin, Minn., to Blackberry Station (Grand Rapids), Minn.*

[Determined by tapeline and azimuth; referred to the Cairo astronomical post.]

Station	Latitude.	Seconds.	Longitude.	Seconds.	Azimuth.	Back azimuth.	To station.	Distance.
	° ′ ″	*Meters.*	° ′ ″	*Meters.*	° ′ ″	° ′ ″		*Meters.*
P. B. M. cut-off	46 35 12.90	398.3	93 39 22.07	469.9	20 09 42.6	200 09 15.6	ⓐ Seeley	2,298.9
					168 18 24.8	348 18 17.1	Hub 1	1,020.7
U. S. E. B. M. 202	46 35 18.05	557.4	93 40 14.94	318.1	227 29 46.6	47 30 17.9	Hub 1	1,243.7
					35 46 56.0		East chimney Elmhurst's house.	
P. B. M. Biggar	46 36 53.37	1,648.0	93 38 58.49	1,244.5	101 38 40.5	281 38 26.8	Hub 3	424.7
					9 02 42.0		North gable Ole Anderson's house.	
					318 54 09.0		North gable Biggar's house.	
					269 29 31.0		West gable Ed Morrison's house.	
P. B. M. Sutton	46 38 36.06	1,113.4	93 37 23.35	496.5	40 23 17.3	220 23 09.2	Hub 7	365.6
U. S. E. B. M. 209	46 39 42.07	1,299.1	93 36 42.23	897.8	359 32 15.2	179 32 15.4	Hub 10	441.8
					4 12 12.0		West gable Smith's house.	
					142 49 26.8		Hub 11.	
P. B. M. Waldeck	46 40 23.73	732.8	93 36 20.77	441.5	33 41 41.1	213 41 29.2	Hub 12	625.9
P. B. M. Fowlds	46 41 18.02	556.4	93 33 18.50	393.1	243 50 45.4	63 50 51.7	Hub 18	204.9
P. B. M. Strand	46 41 45.53	1,406.0	93 30 31.89	677.7	96 21 17.9	276 20 50.6	Hub 21	300.5
					240 26 14.3	60 26 33.5	Hub 22	646.1
					95 53 28.0		West gable Strand's barn.	
P. B. M. Carlson	46 43 18.27	564.2	93 27 29.43	625.1	41 37 03.8	221 36 39.2	Hub 27	1,084.2
					199 47 31.4	19 47 37.1	Hub 28	448.4
					334 31 46.9		North edge chimney Toby Carlson's house.	
P. B. M. School	46 44 42.84	1,322.8	93 24 29.56	627.4	233 26 21.2	53 26 24.4	Hub 34	118.5
					7 36 31.9		North gable Fred Anderson's barn.	
P. B. M. Pat	46 46 16.95	523.4	93 23 04.98	105.7	68 49 25.8	248 49 21.0	Hub 39	151.7
P. B. M. Big Lagoon	46 49 11.34	350.2	93 21 49.34	1,046.0	20 09 15.2	200 09 12.3	Hub 46	247.8
					181 16 51.8	1 16 52.1	Hub 47	300.5
P. B. M. Midway	46 51 32.77	1,011.9	93 21 56.30	1,192.6	121 36 37.1	301 36 31.8	Hub 58	179.8
					255 54 43.0		North corner house L. B.	
					256 42 49.0		South corner house L. B.	
P. B. M. Wells	46 53 32.17	993.4	93 21 53.17	1,125.6	49 12 48.7	229 12 45.9	Hub 66	107.6
					285 16 08.0		Chimney Fred Johnson's house.	
P. B. M. Stone	46 55 01.22	37.7	93 19 41.10	869.7	191 47 13.8	11 47 15.2	Hub 72	193.7
P. B. M. Tiessen	46 59 37.27	1,150.9	93 17 30.87	652.3	180 26 59.7	0 26 59.8	Hub 84	491.8
					15 38 49.6	195 38 41.8	Hub 83	340.4
					195 11 03.0		Chimney Tiessen lower house.	
P. B. M. Vicinity	47 01 40.24	1,242.6	93 18 49.00	1,034.7	72 05 58.6	252 05 51.9	Hub 89	204.1
P. B. M. Shep	47 02 48.37	1,493.7	93 21 11.91	251.2	303 08 48.6	123 08 52.9	Hub 93	151.1
P. B. M. Split Hand	47 03 54.90	1,695.3	93 23 24.48	516.8	6 50 34.4	186 50 31.9	Hub 97	602.2
					145 24 10.0	325 23 53.0	Hub 98	366.4
P. B. M. Hamilton	47 06 12.16	375.5	93 24 40.33	851.6	353 09 36.4	173 09 38.8	Hub 104	466.3
P. B. M. Five Pines	47 08 58.15	1,795.7	93 25 32.12	676.8	295 29 18.8	115 29 18.8	Hub 111	1,107.2
					196 00 37.5	16 00 46.4	Hub 112	927.7

P. B. M. Strawberry	47 10 32.30	1,000.2	93 25 43.30	311.9	331 37 05.0	151 37 29.6	Hub 118..........	1,435.5
					41 08 35.5	221 08 13.2	Ⓐ Porcupine	976.0
					131 12 26.5	311 11 46.0	Ⓐ Zwick..........	1,546.1
Ⓐ Porcupine..................	47 10 08.59	265.3	93 26 13.30	290.6	163 26 48.0	343 26 39.9	Ⓐ Zwick..........	1,829.4
					225 47 00.5	45 48 20.1	B. M. Blackberry	3,188.0
					292 58 48.9	....	Hub 118.	
					338 00 56.6	....	P. B. M. Five Pines.	
Ⓐ Zwick	47 11 05.37	165 8	93 26 33.55	311.5	260 29 35.4	80 31 13.1	B. M. Blackberry..........	2,845.1
B. M. Blackberry	47 11 20.57	635.2	93 24 25.27	531.9				

TABLE No. 2.—*Descriptions and elevations of permanent survey marks, Aitkin, Minn., to Blackberry station (Grand Rapids), Minn., season of 1902.*

P. B. M. Cut-off is tile and pipe, marked 1898, on right bank on north side of Rice River Cut-off, 11 meters north of cut-off, center of narrow strip of bank. Basswood, 22 inches diameter, north 5 feet, blazed with ◬. Cut-off is about 5 miles above Aitkin, Minn. Elevation of top of cap, 1,212.1 feet above Memphis datum.

U. S. E. B. M. 202 is flat stone and iron pipe, established by St. Paul office, in center of road, 10 meters north of gate to river and southwest of corner of house owned by Gasper Vallencourt, opposite to gate in front of house, about 4½ miles above Aitkin, Minn. Elevation of top of cap, 1,211.6 feet above Memphis datum.

P. B. M. Biggar is tile and pipe, marked 1898, on east side of State road, 1 meter from fence, 10 meters south of junction of private road at northwest corner of Biggar Brothers' field, midway between two elm trees blazed with ◬. P. B. M. is 125 meters from right bank of river and 120 meters west of Biggar's house, about 7 miles above Aitkin, Minn. Elevation of top of cap, 1,213 feet above Memphis datum.

P. B. M. Sutton is tile and pipe, marked 1898, 16 meters north of northwest corner of Sutton's house, 1 meter west of fence along east side of State road, 6 meters east of center of road, 28 meters from right bank of river, 20 meters below gully on east side of road, 10 miles above Aitkin, Minn. Elevation of top of cap, 1,215.8 feet above Memphis datum.

U. S. E. B. M. 209 is flat stone and iron pipe 3 meters from right bank of river, near middle of first bend below Waldeck post-office, 39 meters west of Dan Smith's house, a small white frame; 9 meters east of east fence along State road near where road turns west. B. M. was established by St. Paul office. It is about 11 miles above Aitkin, Minn. Elevation of top of cap, 1,217.7 feet above Memphis datum.

P. B. M. Waldeck is tile and pipe, marked 1898, 1 meter west of east fence along State road, on line with east-and-west fence 4 meters north of Waldeck's house and post-office, 30 meters northwest of house, 52 meters from right bank of river, 12 miles above Aitkin, Minn. Elevation of top of cap, 1,218.7 feet above Memphis datum.

P. B. M. Fowlds is tile and pipe, marked 1898, 21 meters from right bank of river, 66 meters northeast of Mrs. Bertha Fowlds's house, 8 meters southwest of State road, one-half meter east of fence in front of Mrs. Fowlds's house, near angle in fence at junction of fences, 15.2 miles above Aitkin, Minn. Elevation of top of cap, 1,219.8 feet above Memphis datum.

P. B. M. Strand is tile and pipe, marked 1898, 1 meter from fence, 3 meters from center State road, 4 meters above angle in fence at end of lane running east from in front of Strand's house, 14 meters from right bank of river, 380 meters below James White's house; 700 meters east of Nelson Strand's house; 30-inch elm southwest 27.7 meters blazed with ◬; about 17.5 miles above Aitkin, Minn. Elevation of top of cap, 1,221.8 feet above Memphis datum.

P. B. M. Carlson is tile and pipe, marked 1898, on east side of State road, 49 meters from right bank, on high sand point at lower edge of balsam thicket, 125 meters below three log houses on right bank. Carlson Hendricks and Toby Carlson live on opposite side of river; about 20 miles above Aitkin, Minn. Elevation of top of cap, 1,236.6 feet above Memphis datum.

P. B. M. School is tile and pipe, marked 1898, lower edge of small poplars 400 meters from right bank of river, 14 meters north of State road, 40 meters above schoolhouse No. 21, 290 meters north of Fred Anderson's house; about 23 miles above Aitkin, Minn. Elevation of top of cap, 1,233.9 feet above Memphis datum.

P. B. M. Pat is B. M. tile and pipe, marked 1898, 7 meters from right bank of river and 5 meters from State road, at log landing belonging to Pat Sanders, 1 mile above Pat Sanders's house, and 26.5 miles above Aitkin, Minn.; 24-inch elm east 15 feet, 10-inch elm south 7 feet; both blazed with ◬ facing P. B. M. Elevation of top of cap, 1,228.5 feet above Memphis datum.

P. B. M. Sandy is B. M. tile and pipe, marked 1898, 8 meters from right bank of river opposite the mouth of Sandy River; 6-inch balm of Gilead 2 meters southeast, 15-inch basswood 2.8 meters south, 10-inch basswood 2.4 meters northwest, 18-inch basswood 2 meters north, 8-inch box elder 4.5 meters northeast; all blazed with ◬ facing P. B. M. Elevation of top of cap, 1,230.5 feet above Memphis datum.

P. B. M. Big Lagoon is ◬ tile and pipe, marked 1898, 5 meters east of State road, on top of right bank of creek draining swamp, 20 meters below center of bridge across creek, 60 meters above junction of State and Doray's roads, 120 meters from right bank of what is known as Big Lagoon; 8-inch spruce 3 meters northeast blazed with ◬; about 30.3 miles above Aitkin, Minn. Elevation of top of cap, 1,235.6 feet above Memphis datum.

P. B. M. Midway is B. M. tile and pipe, marked 1898, on top of knoll covered with boulders, 30 meters from right bank of river, 179.9 meters from State road, 60 meters above mouth of creek, 1,300 meters below what is known as high bank on the river; high country on opposite side of river; 33.8 miles above Aitkin, Minn. Elevation of top of cap, 1,251.7 feet above Memphis datum.

P. B. M. Wells is B. M. tile and pipe, marked 1898, on property of E. B. Wells, 10 meters from right bank of river, 1 meter north and one meter east of northeast corner of Mr. Wells's house, which is Verdon post-office; it is 1¼ meters southeast of 20-inch pine stump, 3 feet high near corner of house; 36.3 miles above Aitkin, Minn. Elevation of top of cap, 1,245.8 feet above Memphis datum.

P. B. M. Stone is B. M. tile and pipe, marked 1898, 3 meters from right bank of river, in edge of meadow; 196 meters above Frank Stone's abandoned house,[a] which is 30 meters above mouth of creek; 125 meters east of State road; 20-inch white oak south 21 meters blazed with ◬; 39 miles above Aitkin, Minn. Elevation of top of cap, 1,248 feet above Memphis datum.

P. B. M. Le Moon is B. M. tile and pipe, marked 1898, 2 meters from top of right bank lagoon, 4 meters east of fence line around John Le Moon's house; State road is between fence and P. B. M.; 15 meters above Le Moon's house; about 41.5 miles above Aitkin, Minn. Elevation of top of cap, 1,254.8 feet above Memphis datum.

P. B. M. Tiessen is ◬ tile and pipe, marked 1898, between State road and right bank of river, 12 meters from former and 20 meters from latter; 402 meters below John Tiessen's house, 100 meters below a cedar-pole bridge across ravine; charred stumps blazed, north 22 feet, east 6.8 feet, southeast 8.5 feet, west 11.5 feet; about 45 miles above Aitkin, Minn. Elevation of top of cap, 1,260.5 feet above Memphis datum.

P. B. M. Vicinity is B. M. tile and pipe, marked 1898, 4 meters from top of bank of old lagoon, in vicinity of county line between Aitkin and Itasca counties; 5-inch oak northeast 25 feet, 9-inch oak north 42 feet, 12-inch oak north 60 feet; all blazed with ◬ facing P. B. M.; 47.5 miles above Aitkin, Minn. Elevation of top of cap, 1,266.6 feet above Memphis datum.

P. B. M. Shep is ◬ tile and pipe, marked 1898, 1¼ miles below Split Hand Creek, 5 meters from right bank of river, on high bank 24 meters from State road; white pine stumps, 40-inch diameter east 18 feet, 30-inch diameter north 18 feet, 24-inch diameter west 15 feet; all blazed with ◬ facing P. B. M.; about 50 miles above Aitkin, Minn Elevation of top of cap, 1,266.5 feet above Memphis datum.

P. B. M. Split Hand is ◬ tile and pipe, marked 1898, about 1,090 meters above Split Hand Creek, 800 meters above John Erwin's house, 6 meters from top of high bank, 105 meters above right bank of river where high bank ends, 40 meters from road; about 52 miles above Aitkin, Minn. Elevation of top of cap, 1,275.3 feet above Memphis datum.

P. B. M. Hamilton is ◬ tile and pipe, marked 1898, 28 meters east from road crossing State road and road from Little Cowhorn Lake and Cowhorn Lagoon and Hamilton's ranch, 4 meters from crossroad; about 54 miles above Aitkin, Minn. Elevation of top of cap, 1,278.3 feet above Memphis datum.

P. B. M. Five Pines is ◬ tile and pipe, marked 1898, on knoll 45 meters from State road northeast and near cluster of five white pines one-half mile above junction of State and Pokegama Lake roads, 375 meters above Edward Heinke's house; 13 meters north of corner of fence; 30-inch white pine west 21 feet, 30-inch white pine south 35 feet, blazed with ◬ facing P. B. M.; about 57 miles above Aitkin, Minn. Elevation of top of cap, 1,292.4 feet above Memphis datum.

P. B. M. Strawberry is ◬ tile and pipe, marked 1898, on knoll 150 meters from right bank of river, three-fourths mile east of hill that ◬⃝ Porcupine is on, and about the same distance south of Phil Zwick's house, about opposite B. M. Blackberry. Elevation of top of cap, 1,308.4 feet above Memphis datum.

◬⃝ Porcupine is ◬ tile and pipe, marked 1898, 14-foot station over mark which is on high ridge 1 mile from river, right bank; a large pond lies at foot of hill on upper side and another on lower side; two tall dead snags 60 meters southwest.

◬⃝ Zwick is ◬ tile and pipe, marked 1898, near east end of high ridge about 400 meters from right bank of river, one-half mile above B. M. Blackberry, which is on left bank 400 meters northwest of Phil Zwick's house.

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[a] Old abandoned house of Frank Stone torn down and new one erected 30 meters west since P. B. M. was set.

TABLE NO. 8.—*Results of precise leveling, Aitkin, Minn., to Grand Rapids, Minn. (Blackberry station), 1902.*

[E. L. HARMAN, leveler.]

Benchmark.	Determined from—	Length of stretch.	Distance from initial point.	Direction.	Difference of elevation.	Residuals =V.	Σ V Direct line.	Σ V Reverse line.	r ±	R ±	Rod correction.	Loop adjustment.	Elevation above Cairo datum.	
		Meters.	*Km.*		*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Meters.*	*Feet.*
P. B. M. Court-house, Aitkin, Minn.												+7.7	376.7758	1,236.152
T. B. M. 259 W (1898)	P. B. M. Court-house.	89	0.089	First direct First reverse Second direct Second reverse	−2,450.1 −2,450.2 −2,451.1 −2,450.7	−0.42 −0.32 +0.58 +0.18	+0.07	−0.07	0.16	0.2	−0.2	+7.7	374.3251	
				Mean	−2,450.52									
T. B. M. 1	T. B. M. 259 W (1898).	954	1.043	First direct First reverse Second direct Second reverse	−1,964.0 −1,960.2 −1,964.3 −1,961.7	+1.45 −2.35 +1.75 −0.85	+1.67	−1.67	.66	.7	−0.4	+7.8	372.3624	
				Mean	−1,962.55									
P. B. M. $\frac{2}{19}$; bolt in tile	T. B. M. 1	44	1.087	Direct Reverse	−1,058.7 −1,059.0	−0.15 +0.15	+1.52	−1.52	.10	.7	−0.5	+7.8	371.3085	1,218.198
				Mean	−1,058.85									
P. B. M. $\frac{2}{32}$; cap on pipe	T. B. M. 1	44	1.087	Direct Reverse	+ 152.3 + 152.3	0.0 0.0	+1.52	−1.52	.00	.7	−0.4	+7.8	372.5147	1,222.172
				Mean	+ 152.3									
T. B. M. 3	T. B. M. 1	586	1.629	First direct First reverse Second direct Second reverse	a 719.2 − 723.8 − 724.3 − 724.8	 −0.50 0.00 +0.50	+1.23	−1.23	.19	.7	−0.5	+7.8	371.6380	
				Mean	− 724.3									
T. B. M. 273 W (1898)	T. B. M. 3	701	2.330	First direct Reverse Second direct	a + 682.0 + 675.2 + 677.3	 +1.05 −1.05	+0.18	−0.18	.70	1.0	−0.4	+7.8	372.3144	
				Mean	+ 676.25									

Ⓐ Lower base (Aitkin); bolt in tile.	T. B. M. 273 W (1898).	26	2.356	Direct	− 946.7	−0.30	−0.12	+0.12	.20	1.0	−0.5	+7.8	371.3678	1,218.406
				Reverse	− 947.3	+0.30								
				Mean	− 947.00									
ⓐ Lower base (Aitkin); cap on pipe.	T. B. M. 273 W (1898).	26	2.356	Direct	+ 266.7	0.00	+0.18	−0.18	.00	1.0	−0.4	+7.8	372.5811	1,222.390
				Reverse	+ 266.7	0.00								
				Mean	+ 266.7									
T. B. M. 2	T. B. M. 1	211	1.254	Direct	+ 210.7	+0.05	+1.72	−1.72	.08	.7	−0.4	+7.8	372.5732	....
				Reverse	+ 210.8	−0.05								
				Mean	+ 210.75									
B. M. $\frac{3}{18}$; bolt in tile	T. B. M. 2	62	1.316	Direct	−1,225.7	−0.15	+1.57	−1.57	.10	.7	−0.5	+7.8	371.3472	1,218.342
				Reverse	−1,226.0	+0.15								
				Mean	−1,225.85									
B. M. $\frac{3}{19}$; cap on pipe	T. B. M. 2	62	1.316	Direct	− 12.0	0.00	+1.72	−1.72	.00	.7	−0.4	+7.8	372.5612	1,222.325
				Reverse	− 12.0	0.00								
				Mean	− 12.0									
T. B. M. 4	T. B. M. 2	567	1.821	Direct	−1,104.8	−0.75	+0.97	−0.97	.50	.8	−0.5	+7.9	371.4676	....
				Reverse	−1,106.3	+0.75								
				Mean	−1,105.55									
T. B. M. 5	T. B. M. 4	1,715	3.536	Direct	+1,228.3	−0.40	+0.57	−0.57	.27	.9	−0.4	+8.1	372.6958	....
				Reverse	+1,227.5	+0.40								
				Mean	+1,227.9									
T. B. M. 6	T. B. M. 5	1,570	5.106	Direct	+ 217.2	0.0	+0.57	−0.57	.00	.9	−0.4	+8.3	372.9182	....
				Reverse	+ 217.2									
				Mean	+ 217.2									
T. B. M. 7	T. B. M. 6	1,792	6.898	Direct	− 212.8	−0.60	−0.08	+0.08	.40	1.0	−0.4	+8.5	372.7000	....
				Reverse	− 214.0	+0.60								
				Mean	+ 213.4									
U. S. E. B. M. 202; cap on pipe	T. B. M. 7	671	7.569	First direct	+ 606.6	−2.40	−1.50	+1.50	.98	1.4	−0.3	+8.6	373.3044	1,224.763
				Reverse	+ 601.6	+2.60								
				Second direct	+ 604.4	−0.20								
				Mean	+ 604.2									

a Rejected.

TABLE NO. 3.—*Results of precise leveling, Aitkin, Minn., to Grand Rapids, Minn. (Blackberry station), 1902*—Continued.

Benchmark.	Determined from—	Length of stretch.	Distance from initial point.	Direction.	Difference of elevation.	Residuals =V.	Σ V Direct line.	Σ V Reverse line.	r ±	R ±	Rod correction.	Loop adjustment.	Elevation above Cairo datum.	
		Meters.	*Km.*		*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm*	*Meters.*	*Feet.*
T. B. M. 8	U. S. E. B. M. 202, cap on pipe.	1,404	8.973	Direct	+1,012.2	+0.65	−0.85	+0.85	.43	1.4	−0.2	+8.7	374.3175	....
				Reverse	+1,013.5	−0.65								
				Mean	+1,012.85									
T. M. B. 9	T. B. M. 8	1,083	10.056	Direct	−1,221.0	−0.75	−1.60	+1.60	.50	1.5	--0.4	+8.7	373.0955	....
				Reverse	−1,222.5	+0.75								
				Mean	−1,221.75									
P. B. M. cut-off; bolt in tile	T. B. M. 9	80	10.136	Direct	− 845.2	+0.60	−1.00	+1.00	.40	1.6	−0.4	+8.7	372.2509	1,221.307
				Reverse	− 844.0	−0.60								
				Mean	− 844.6									
P. B. M. cut-off; cap on pipe	T. B. M. 9	80	10.136	Direct	+ 372.8	−0.05	−1.65	+1.65	.03	1.5	−0.3	+8.7	373.4684	1,225.301
				Reverse	+ 372.7	+0.05								
				Mean	+ 372.75									
T. B. M. 10	T. B. M. 8	1,812	10.785	Direct	− 522.5	+0.25	−0.60	+0.60	.17	1.4	−0.3	+8.9	373.7953	....
				Reverse	− 522.0	−0.25								
				Mean	− 522.25									
T. B. M. 12	T. B. M. 10	475	11.260	Direct	− 73.7	0.00	−0.60	+0.60	.00	1.4	−0.3	+8.9	373.7216	....
				Reverse	− 73.7	0.00								
				Mean	− 73.7									
P. B. M. Biggar; bolt in tile	T. B. M. 12	23	11.283	Direct	−1,196.0	+0.10	−0.50	+0.50	.07	1.5	−0.4	+8.9	372.5256	1,222.208
				Reverse	−1,195.8	−0.10								
				Mean	−1,195.9									
P. B. M. Biggar; cap on pipe	T. B. M. 12	23	11.283	Direct	+ 18.0	−0.15	−0.75	+0.75	.10	1.5	−0.8	+8.9	373.7395	1,226.190
				Reverse	+ 17.7	+0.15								
				Mean	+ 17.85									

T. B. M. 11	T. B. M. 10	1,262	12.047	Direct	+1,012.2	+0.65	+0.05	−0.05	.43	1.5	−0.2	+9.1	374.8085	....
				Reverse	+1,013.5	−0.65								
				Mean	+1,012.85									
T. B. M. 13	T. B. M. 11	1,812	13.859	Direct	+1,162.7	−1.25	−1.20	+1.20	.83	1.7	−0.1	+9.3	375.9702	....
				Reverse	+1,160.2	+1.25								
				Mean	+1,161.45									
T. B. M. 14	T. B. M. 13	966	14.825	Direct	− 705.7	−0.15	−1.35	+1.35	.10	1.7	−0.2	+9.4	375.2644	....
				Reverse	− 706.0	+0.15								
				Mean	− 705.85									
T. B. M. 15	T. B. M. 14	983	15.808	Direct	− 972.5	−1.35	−2.70	+2.70	.90	2.0	−0.2	+9.5	374.2906	....
				Reverse	− 975.2	+1.35								
				Mean	− 973.85									
P. B. M. Sutton; bolt in tile	T. B. M. 15	79	15.887	Direct	− 919.0	+0.15	−2.55	+2.55	.10	2.0	−0.3	+9.5	373.3717	1,224.984
				Reverse	− 918.7	−0.15								
				Mean	− 918.85									
P. B. M. Sutton; cap on pipe	T. B. M. 15	79	15.887	Direct	+ 300.7	−0.25	−2.80	+2.80	.17	2.0	−0.2	+9.5	374.5911	1,228.984
				Reverse	+ 300.2	+0.25								
				Mean	+ 300.45									
T. B. M. Raynor	P. B. M. Sutton, cap on pipe.	29	15.916	Direct	− 999.0	0.00	−2.80	+2.80	.00	2.0	−0.3	+ 9.5	373.5920	1,225.707
				Reverse	− 999.0	0.00								
				Mean	− 999.0									
H. W. Mark, 1888	P. B. M. Sutton, cap on pipe.	28	15.915	Direct	− 25.8	+0.30	−2.50	+2.50	.20	2.0	−0.2	+ 9.5	374.5656	1,228.901
				Reverse	− 25.2	−0.30								
				Mean	− 25.5									
T. B. M. 16	T. B. M. 15	1,273	17.081	Direct	+3,078.0	−1.50	−4.20	+4.20	1.00	2.2	+0.1	+ 9.6	377.3675	....
				Reverse	+3,075.0	+1.50								
				Mean	+3,076.5									
T. B. M. 17	T. B. M. 16	1,119	18.200	Direct	−2,554.8	−0.85	−5.05	+5.05	.57	2.3	−0.2	+ 9.8	374.8118	....
				Reverse	−2,556.5	+0.85								
				Mean	−2,555.65									

TABLE NO. 8.—*Results of precise leveling, Aitkin, Minn., to Grand Rapids, Minn. (Blackberry station), 1902*—Continued.

Benchmark.	Determined from—	Length of stretch.	Distance from initial point.	Direction.	Difference of elevation.	Residuals =V.	Σ V		r	R	Rod correction.	Loop adjustment.	Elevation above Cairo datum.	
							Direct line.	Reverse line.	±	±				
		Meters.	*Km.*		*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Meters.*	*Feet.*
U. S. E. B. M. 209; bolt in stone.	T. B. M. 17	168	18.868	Direct Reverse	− 861.7 − 862.0	−0.15 +0.15	−5.20	+5.20	.10	2.3	−0.3	+ 9.8	373.9496	1,226.880
				Mean	− 861.85									
U. S. E. B. M. 209, cap on pipe.	T. B. M. 17	168	18.868	Direct Reverse	+ 343.3 + 343.3	0.00 0.00	−5.05	+5.05	.00	2.3	−0.2	+ 9.8	375.1551	1,230.835
				Mean	+ 343.3									
T. B. M. 18	T. B. M. 17	1,497	19.697	Direct Reverse	+ 19.0 + 20.3	+0.65 −0.65	−4.40	+4.40	.43	2.3	−0.2	+ 9.9	374.8315	....
				Mean	+ 19.65									
P. B. M. Waldeck; bolt in tile.	T. B. M. 18	67	19.764	Direct Reverse	− 573.3 − 573.7	−0.20 +0.20	−4.60	+4.60	.13	2.3	−0.2	+ 9.9	374.2580	1,227.892
				Mean	− 573.5									
P. B. M. Waldeck; cap on pipe.	T. B. M. 18	67	19.764	Direct Reverse	+ 638.2 + 638.0	−0.10 +0.10	−4.50	+4.50	.07	2.3	−0.2	+ 9.9	375.4696	1,231.867
				Mean	+ 638.1									
H. W. Mark, 1899	P. B. M. Waldeck, cap on pipe.	48	19.812	Direct Reverse	− 517.2 − 517.0	+0.10 −0.10	−4.40	+4.40	.07	2.3	−0.2	+ 9.9	374.9625	1,230.170
				Mean	− 517.1									
T. B. M. 19	T. B. M. 18	568	20.265	First direct First reverse Second direct Second reverse	− 196.3 − 201.3 − 197.8 − 200.0	−2.55 +2.45 −1.05 +1.15	−6.20	+6.20	.75	2.4	−0.2	+10.0	374.6328	....
				Mean	− 198.85									
T. B. M. 20	T. B. M. 19	994	21.259	Direct Reverse	+ 483.7 + 480.2	−1.75 +1.75	−7.95	+7.95	1.17	2.7	0.2	+10.1	375.1148	....
				Mean	+ 481.95									

T. B. M. 21	T. B. M. 20	1,848	23.108	Direct Reverse	+ 50.3 + 52.0	+0.85 −0.85	−7.10	+7.10	.57	2.8	−0.2	+10.4	875.1663	....
				Mean	+ 51.15									
T. B. M. 22	T. B. M. 21	688	23.785	Direct Reverse	+ 960.7 + 962.0	+0.65 −0.65	−6.45	+6.45	.43	2.8	−0.1	+10.5	876.1278	....
				Mean	+ 961.35									
T. B. M. 23	T. B. M. 22	758	24.538	Direct Reverse	− 105.3 − 107.0	−0.85 +0.85	−7.80	+7.80	.57	2.8	−0.1	+10.6	876.0218	....
				Mean	− 106.15									
P. B. M. Fowlds; bolt in tile.	T. B. M. 23	26	24.564	Direct Reverse	−1,426.7 −1,426.0	+0.35 −0.35	−6.95	+6.95	.23	2.9	−0.2	+10.6	874.5953	1,228.998
				Mean	−1.426.35									
P. B. M. Fowlds; cap on pipe.	T. B. M. 23	26	24.564	Direct Reverse	− 210.2 − 210.0	+0.10 −0.10	−7.20	+7.20	.07	2.8	−0.1	+10.6	875.8117	1,232.989
				Mean	− 210.1									
T. B. M. 24	T. B. M. 23	1,080	25.568	Direct Reverse	− 129.5 − 132.4	−1.45 +1.45	−8.75	+8.75	.97	3.0	−0.1	+10.7	875.8909	....
				Mean	− 130.95									
T. B. M. 25	T. B. M. 24	1,273	26.841	Direct Reverse	+4,371.5 +4,372.7	+0.60 −0.60	−8.15	+8.15	.40	3.0	+0.5	+10.9	880.2638	....
				Mean	+4,372.1									
T. B. M. 26	T. B. M. 25	1,443	28.284	Direct Reverse	−4,043.3 −4,042.0	+0.65 −0.65	−7.50	+7.50	.43	3.1	−0.1	+11.0	876.2207	....
				Mean	−4,042.65									
P. B. M. Strand; bolt in tile.	T. B. M. 26	27	28.311	Direct Reverse	−1,027.3 −1,028.8	−0.25 +0.25	−7.75	+7.75	.17	3.1	−0.2	+11.0	875.1925	1,230.958
				Mean	−1,028.05									
P. B. M. Strand; cap on pipe.	T. B. M. 26	27	28.311	Direct Reverse	+ 180.3 + 180.0	−0.15 +0.15	−7.65	+7.65	.10	3.1	0.0	+11.0	876.4009	1,234.922
				Mean	+ 180.15									

TABLE NO. 3.—*Results of precise leveling, Aitkin, Minn., to Grand Rapids, Minn. (Blackberry station), 1902*—Continued.

Benchmark.	Determined from—	Length of stretch.	Distance from initial point.	Direction.	Difference of elevation.	Residuals =V.	Σ V Direct line.	Σ V Reverse line.	r ±	R ±	Rod correction.	Loop adjustment.	Elevation above Cairo datum.	
		Meters.	*Km.*		*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Meters.*	*Feet.*
T. B. M. 27	T. B. M. 26	1,735	30.019	Direct	+ 937.5	−0.10	−7.60	+7.60	.07	3.1	0.0	+11.2	377.1584	
				Reverse	+ 937.3	+0.10								
				Mean	+ 937.4									
T. B. M. 28	T. B. M. 27	772	30.791	Direct	− 62.3	−0.35	−7.95	+7.95	.23	3.1	0.0	+11.3	377.0958	
				Reverse	− 63.0	+0.35								
				Mean	− 62.65									
T. B. M. 29	T. B. M. 28	741	31.532	Direct	+ 294.5	+1.93	−6.60	+6.60	.90	3.2	+0.1	+11.4	377.3925	
				First reverse	+ 299.0	−2.57								
				Second reverse	+ 295.8	+0.63								
				Mean	+ 296.43									
T. B. M. 30	T. B. M. 29	2,033	33.565	Direct	+3,276.5	−0.75	−7.35	+7.35	.50	3.2	+0.4	+11.6	380.6687	
				Reverse	+3,275.0	+0.75								
				Mean	+3,275.75									
P. B. M., Carlson; bolt in tile.	T. B. M. 30	36	33.601	First direct	− 944.8	+0.42	−7.38	+7.38	.15	3.2	+0.3	+11.6	379.7242	1,245.825
				First reverse	− 944.0	−0.38								
				Second direct	− 944.0	−0.38								
				Second reverse	− 944.7	+0.32								
				Mean	− 944.38									
P. B. M., Carlson; cap on pipe	T. B. M. 30	36	33.601	Direct	+ 267.8	−0.30	−7.65	+7.65	.20	3.2	+0.4	+11.6	380.9362	1,249.802
				Reverse	+ 267.2	+0.30								
				Mean	+267.5									
T. B. M. 31	T. B. M. 30	661	34.226	First direct	−1,247.7	−2.10	−8.15	+8.15	.74	3.3	+0.3	+11.7	379.4189	
				First reverse	−1,252.7	+2.90								
				Second direct	−1,250.3	+0.50								
				Second reverse	−1,248.5	−1.30								
				Mean	−1,249.8									

T. B. M. 32	T. B. M. 31	880	34.556	Direct	− 862.8	−0.10	−8.25	+8.25	.07	3.3	+0.2	+11.7	378.5559	....
				Reverse	− 863.0	+0.10								
				Mean	− 862.9									
T. B. M. 33	T. B. M. 32	822	35.378	First direct	+1,520.5	−2.75	−8.50	+8.50	.74	3.4	+0.8	+11.8	380.0739	....
				First reverse	+1,516.5	+1.25								
				Second direct	+1,515.5	+2.25								
				Second reverse	+1,518.5	−0.75								
				Mean	+1,517.75									
T. B. M. 34	T. B. M. 33	1,418	36.796	Direct	−1,392.0	+1.35	−7.15	+7.15	.90	3.5	+0.2	+12.0	378.6838	....
				Reverse	−1,389.3	−1.35								
				Mean	−1,390.65									
T. B. M. 35	T. B. M. 34	1,748	38.544	Direct	+ 799.3	+0.75	−6.40	+6.40	.50	3.6	+0.8	+12.2	379.4837	....
				Reverse	+ 800.8	−0.75								
				Mean	+ 800.05									
P. B. M. school; bolt in tile	T. B. M. 35	23	38.567	Direct	− 603.5	+0.15	−6.25	+6.25	.10	3.6	+0.2	+12.2	378.8802	1,243.056
				Reverse	− 603.2	−0.15								
				Mean	− 603.35									
P. B. M. school; cap on pipe.	T. B. M. 35	23	38.567	Direct	+ 608.3	+0.10	−6.30	+6.30	.07	3.6	+0.8	+12.2	380.0921	1,247.082
				Reverse	+ 608.5	−0.10								
				Mean	+ 608.4									
T. B. M. 36	T. B. M. 35	1,129	39.673	Direct	−2,598.8	+1.15	−5.25	+5.25	.77	3.6	0.0	+12.3	376.8858	....
				Reverse	−2,596.5	−1.15								
				Mean	−2,597.65									
T. B. M. 37	T. B. M. 36	1,380	41.053	Direct	+3,501.5	+0.25	−5.00	+5.00	.17	3.6	+0.4	+12.5	380.3882	....
				Reverse	+3,502.0	−0.25								
				Mean	+3,501.75									
T. B. M. 38	T. B. M. 37	1,613	42.666	Direct	−2,244.2	−1.25	−6.25	+6.25	.88	3.7	+0.1	+12.7	378.1428	....
				Reverse	−2,246.7	+1.25								
				Mean	−2,245.45									
P. B. M. Pat; bolt in tile	T. B. M. 38	21	42.687	Direct	− 900.7	−0.15	−6.40	+6.40	.10	3.7	0.0	+12.7	377.2417	1,237.681
				Reverse	− 901.0	+0.15								
				Mean	− 900.85									

TABLE NO. 3.—*Results of precise leveling, Aitkin, Minn., to Grand Rapids, Minn. (Blackberry station), 1902*—Continued.

Benchmark.	Determined from—	Length of stretch.	Distance from initial point.	Direction.	Difference of elevation.	Residuals =V.	Σ V		r ±	R ±	Rod correction.	Loop adjustment.	Elevation above Cairo datum.	
							Direct line.	Reverse line.						
		Meters.	*Km.*		*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Meters.*	*Feet.*
P. B. M. Pat; cap on pipe	T. B. M. 38	21	42.687	Direct	+ 311.8	+0.10	−6.15	+6.15	.07	3.7	+0.2	+12.7	378.4546	1,241.660
				Reverse	+ 312.0	−0.10								
				Mean	+ 311.9									
T. B. M. 39	T. B. M. 38	1,514	44.180	Direct	+2,984.0	+0.10	−6.15	+6.15	.07	3.7	+0.4	+12.8	381.1271	....
				Reverse	+2,984.2	−0.10								
				Mean	+2,984.1									
T. B. M. 41	T. B. M. 39	1,194	45.374	First direct	+ 506.8	+1.72	−5.53	+5.53	.64	3.8	+0.5	+13.0	381.6359	....
				First reverse	+ 511.0	−2.48								
				Second direct	+ 509.0	−0.48								
				Second reverse	+ 507.3	+1.22								
				Mean	+ 508.52									
T. B. M. 42	T. B. M. 41	1,246	46.620	Direct	+2,568.2	−1.00	−6.53	+6.53	.67	3.9	+0.7	+13.1	384.2084	....
				Reverse	+2,566.2	+1.00								
				Mean	+2,567.2									
T. B. M. 43	T. B. M. 42	1,516	48.136	Direct	−4,723.6	+0.80	−5.73	+5.73	.53	3.9	+0.3	+13.3	379.4804	....
				Reverse	−4,722.0	−0.80								
				Mean	−4,722.8									
T. B. M. 44	T. B. M. 43	2,368	50.504	Direct	− 393.8	−0.75	−6.48	+6.48	.50	3.9	+0.2	+13.3	379.0858	....
				Reverse	− 395.3	+0.75								
				Mean	− 394.55									
P. B. M. Sandy; bolt in tile	T. B. M. 44	21	50.525	Direct	−1,237.3	0.00	−6.48	+6.48	.00	3.9	+0.1	+13.3	377.8484	1,239.671
				Reverse	1,237.3	0.00								
				Mean	−1,237.3									
P. B. M. Sandy; cap on pipe	T. B. M. 44	21	50.525	Direct	− 29.3	+0.15	−6.33	+6.33	.10	3.9	+0.2	+13.3	379.0566	1,243.635
				Reverse	− 29.0	−0.15								
				Mean	− 29.15									

U.S.E.B.M	T.B.M.44	135	50.639	Direct..........	−1,707.5	−0.10	−6.58	+6.58	.07	3.9	+0.1	+13.3	377.3781	1,238.128
				Reverse........	−1,707.7	+0.10								
				Mean........	−1,707.6									
T.B.M.45	T.B.M.43	647	48.783	First direct....	− 447.0	+3.15	−4.43	+4.43	.80	4.0	+0.2	+13.4	379.0966	....
				First reverse ..	− 443.8	−0.05								
				Second direct..	− 443.3	−0.55								
				Second reverse	− 441.3	−2.55								
				Mean.......	− 443.85									
T.B.M.46	T.B.M.45	1,941	50.724	Direct..........	+1,439.5	+0.65	−3.78	+3.78	.43	4.0	+0.4	+13.6	380.4771	....
				Reverse........	+1,440.8	−0.65								
				Mean.......	+1,440.15									
P. B. M. Big Lagoon; bolt in tile.	T.B.M.46	22	50.746	Direct..........	−1,071.3	+0.15	−3.68	+3.68	.10	4.0	+0.3	+13.6	379.4059	1,244.781
				Reverse........	−1,071.0	−0.15								
				Mean.......	−1,071.15									
P. B. M. Big Lagoon; cap on pipe.	T.B.M.46	22	50.746	Direct..........	+ 148.0	−0.35	−4.13	+4.13	.23	4.0	+0.4	+13.6	380.6248	1,248.780
				Reverse........	+ 147.3	+0.35								
				Mean.......	+ 147.65									
T.B.M.47	T.B.M.46	1,123	51.852	Direct..........	−1,057.2	−1.55	−5.38	+5.38	1.03	4.1	+0.3	+13.7	379.4184	....
				Reverse........	−1,060.3	+1.55								
				Mean. :	−1.058.75									
T.B.M.48	T.B.M.47	701	52.553	Direct..........	+ 759.0	−1.25	−6.58	+6.58	.83	4.2	+0.3	+13.8	380.1762	....
				Reverse........	+ 756.5	+1.25								
				Mean.......	+ 757.75									
T.B.M.49	T.B.M.48	1,379	53.982	Direct..........	+2,969.0	−0.10	−6.68	+6.68	.07	4.2	+0.6	+13.9	383.1455	....
				Reverse........	+2,968.8	+0.10								
				Mean.......	+2,968.9									
T.B.M.50	T.B.M.49	2,136	56.118	Direct..........	−2,005.8	+0.15	−6.53	+6.53	.10	4.2	+0.4	+14.2	381.1400	....
				Reverse........	−2,005.5	−0.15								
				Mean.......	−2,005.65									
P.B.M. Midway; bolt in tile.	T.B.M.50	127	56.245	Direct..........	+3,154.5	−0.10	−6.63	+6.63	.07	4.2	+0.3	+14.2	384.2948	1,260.821
				Reverse........	+3,154.3	+0.10								
				Mean.......	+3,154.4									

TABLE NO. 3.—*Results of precise leveling, Aitkin, Minn., to Grand Rapids, Minn. (Blackberry station), 1902*—Continued.

Benchmark.	Determined from—	Length of stretch.	Distance from initial point.	Direction.	Difference of elevation.	Residuals =V.	Σ V		r	R	Rod correction.	Loop adjustment.	Elevation above Cairo datum.	
							Direct line.	Reverse line.	±	±				
		Meters.	*Km.*		*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Meters.*	*Feet.*
P. B. M. Midway; cap on pipe	P. B. M. Midway; bolt in tile.	61	56.306	Direct	+1,221.2	−0.45	−7.08	+7.08	.80	4.2	+0.9	+14.2	385.5156	1,264.826
				Reverse	+1,220.3	+0.45								
				Mean	+1,220.75									
T. B. M. 51	T. B. M. 50	889	57.007	Direct	+4,157.2	−0.20	−6.78	+6.78	.13	4.2	+0.9	+14.3	385.2976	....
				Reverse	+4,156.8	+0.20								
				Mean	+4,157.0									
T. B. M. 52	T. B. M. 51	899	57.906	First direct	+ 62.5	+1.82	−6.06	+6.06	1.00	4.3	+0.9	+14.4	385.3620	....
				First reverse	+ 68.3	−3.98								
				Second direct	+ 64.8	−0.48								
				Second reverse	+ 61.7	+2.62								
				Mean	+ 64.32									
T. B. M. 53	T. B. M. 52	2,229	60.135	Direct	−1,729.5	+1.60	−4.46	+4.46	1.07	4.5	+0.7	+14.7	383.6342	....
				Reverse	−1,726.3	−1.60								
				Mean	−1,727.9									
P. B. M. Wells; bolt in tile	T. B. M. 53	21	60.156	Direct	−1,101.3	+0.15	−4.31	+4.31	.10	4.5	+0.6	+14.7	382.5329	1,255.040
				Reverse	−1,101.0	−0.15								
				Mean	−1,101.15									
P. B. M. Wells; cap on pipe	T. B. M. 53	21	60.156	Direct	+ 110.0	−0.15	−4.61	+4.61	.10	4.5	+0.7	+14.7	383.7440	1,259.014
				Reverse	+ 109.7	+0.15								
				Mean	+ 109.85									
T. B. M. 54	T. B. M. 53	2,206	62.341	Direct	+ 584.7	−0.35	−4.81	+4.81	.23	4.5	+0.7	+14.9	384.2187	....
				Reverse	+ 584.0	+0.35								
				Mean	+ 584.35									
T. B. M. 55	T. B. M. 54	2,191	64.532	Direct	− 83.7	+1.10	−3.71	+3.71	.73	4.5	+0.7	+15.1	384.1368	....
				Reverse	− 81.5	−1.10								
				Mean	− 82.6									

P. B. M. Stone; bolt in tile..	T. B. M. 55	50	64.589	Direct..........	− 941.8	−0.85	−4.06	+4.06	.23	4.5	+0.6	+15.1	383.1946	1,257.211
				Reverse........	− 942.0	+0.85								
				Mean.......	− 941.65									
P. B. M. Stone; cap on pipe.	T. B. M. 55	50	64.582	Direct..........	+ 271.8	0.00	−3.71	+3.71	.00	4.5	+0.8	+15.1	384.4082	1,261.193
				Reverse........	+ 271.8	0.00								
				Mean.......	+ 271.8									
T. B. M. 56..................	T. B. M. 55	758	65.285	Direct..........	−2,212.3	−0.45	−4.16	+4.16	.80	4.5	+0.5	+15.2	381.9235	....
				Reverse........	−2,213.2	+0.45								
				Mean.......	−2,212.75									
T. B. M. 57..................	T. B. M. 56	210	65.495	Direct..........	+2,460.7	+0.55	−3.61	+3.61	.37	4.5	+0.8	+15.3	384.3851	....
				Reverse........	+2,461.8	−0.55								
				Mean.......	+2,461.25									
T. B. M. 58..................	T. B. M. 57	473	65.968	First direct....	−1,768.0	+1.55	−2.31	+2.31	.51	4.6	+0.6	+15.3	382.6185	....
				First reverse ..	−1,765.3	−1.15								
				Second direct..	−1,767.5	+1.05								
				Second reverse	−1,765.0	−1.45								
				Mean.......	−1,766.45									
T. B. M. 59..................	T. B. M. 58	618	66.586	Direct..........	+2,825.0	+1.35	−0.96	+0.96	.90	4.7	+0.9	+15.4	385.4452	....
				Reverse........	+2,827.7	−1.35								
				Mean.......	+2,826.35									
T. B. M. 60..................	T. B. M. 59	647	67.233	Direct..........	− 106.2	+0.95	−0.01	+0.01	.63	4.7	+0.9	+15.5	385.8401	....
				Reverse........	− 104.3	−0.95								
				Mean.......	− 105.25									
T. B. M. 61..................	T. B. M. 60	1,742	68.975	Direct..........	+ 689.0	+1.40	+1.39	−1.39	.98	4.8	+0.9	+15.7	386.0807	....
				Reverse........	+ 691.8	−1.40								
				Mean.......	+ 690.4									
T. B. M. 62..................	T. B. M. 61	1,299	70.274	Direct..........	− 194.8	+0.80	+2.19	−2.19	.58	4.8	+0.9	+15.8	385.8368	....
				Reverse........	− 193.2	−0.80								
				Mean.......	− 194.0									
P. B. M. Le Moon; bolt in tile	T. B. M. 62	75	70.349	Direct..........	− 557.8	−0.20	+1.99	−1.99	.13	4.8	+0.8	+15.8	385.2787	1,264.049
				Reverse........	− 558.2	+0.20								
				Mean.......	− 558.0									

TABLE NO. 3.—*Results of precise leveling, Aitkin, Minn., to Grand Rapids, Minn.* (*Blackberry station*), *1902*—Continued.

Benchmark.	Determined from—	Length of stretch.	Distance from initial point.	Direction.	Difference of elevation.	Residuals =V.	Σ V		r	R	Rod correction.	Loop adjustment.	Elevation above Cairo datum.	
							Direct line.	Reverse line.	±	±				
		Meters.	*Km.*		*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Meters.*	*Feet.*
P. B. M. Le Moon; cap on pipe.	T. B. M. 62	75	70.849	Direct	+ 654.5	+0.10	+2.29	−2.29	.07	4.8	+1.0	+15.8	386.4915	1,268.028
				Reverse	+ 654.7	−0.10								
				Mean	+ 654.60									
T. B. M. 63	T. B. M. 62	1,542	71.816	Direct	+1,075.0	−0.60	+1.59	−1.59	.40	4.8	+1.1	+16.0	386.9116	....
				Reverse	+1,073.8	+0.60								
				Mean	+1,074.4									
T. B. M. 64	T. B. M. 63	2,146	73.962	Direct	− 494.2	−0.15	+1.44	−1.44	.10	4.8	+1.1	+16.2	386.4174	....
				Reverse	− 494.5	+0.15								
				Mean	− 494.35									
T. B. M. 65	T. B. M. 64	1,255	75.217	Direct	+1,555.7	+0.40	+1.84	−1.84	.27	4.9	+1.2	+16.4	387.9788	....
				Reverse	+1,556.5	−0.40								
				Mean	+1,556.1									
P. B. M. Tiessen; bolt in tile	T. B. M. 65	28	75.245	Direct	− 958.7	−0.15	+1.69	−1.69	.10	4.9	+1.1	+16.4	387.0149	1,269.745
				Reverse	− 959.0	+0.15								
				Mean	− 958.85									
P. B. M. Tiessen; cap on pipe	T. B. M. 65	28	75.245	Direct	+ 256.0	+0.35	+2.19	−2.19	.23	4.9	+1.2	+16.4	388.2802	1,273.782
				Reverse	+ 256.7	−0.35								
				Mean	+ 256.35									
T. B. M. 66	T. B. M. 65	1,322	76.539	Direct	−2,601.3	−0.35	+1.49	−1.49	.23	4.9	+0.9	+16.5	385.8720	....
				Reverse	−2,602.0	+0.35								
				Mean	−2,601.65									
T. B. M. 67	T. B. M. 66	1,955	78.494	Direct	+2,931.0	−1.35	+0.14	−0.14	.90	4.9	+1.8	+16.7	388.3022	....
				Reverse	+2,928.3	+1.35								
				Mean	+2,929.65									

T. B. M. 68	T. B. M. 67	761	79.255	Direct	+1,114.0	−0.50	−0.36	+0.36	.33	4.9	+1.4	+16.8	889.4159	....
				Reverse	+1,113.0	+0.50								
				Mean	+1,113.5									
T. B. M. 69	T. B. M. 68	755	80.010	Direct	+ 518.7	−1.10	−1.46	+1.46	.73	5.0	+1.4	+16.9	889.9336	....
				Reverse	+ 516.5	+1.10								
				Mean	+ 517.6									
P. B. M. Vicinity; bolt in tile.	T. B. M. 69	38	80.048	First direct	−1,054.0	−0.72	−1.78	+1.78	.18	5.0	+1.8	+16.9	888.8788	1,275.860
				First reverse	−1,054.8	+0.08								
				Second direct	−1,054.8	+0.08								
				Second reverse	−1,055.3	+0.58								
				Mean	−1,054.72									
P. B. M. Vicinity; cap on pipe.	T. B. M. 69	38	80.048	Direct	+ 156.8	0.00	−1.46	+1.46	.00	5.0	+1.4	+16.9	890.0899	1,279.834
				Reverse	+ 156.8	0.00								
				Mean	+ 156.8									
T. B. M. 70	T. B. M. 69	2,543	82.553	Direct	+ 552.8	−1.50	−2.96	+2.96	1.00	5.1	+1.5	+17.2	890.4853	....
				Reverse	+ 549.8	+1.50								
				Mean	+ 551.30									
T. B. M. 71	T. B. M. 70	1,427	83.980	Direct	− 386.7	−0.15	−3.11	+3.11	.10	5.1	+1.4	+17.4	890.0986	....
				Reverse	− 387.0	+0.15								
				Mean	− 386.85									
P. B. M. Shep; bolt in tile	T. B. M. 71	15	83.995	Direct	−1,266.0	0.00	−3.11	+3.11	.00	5.1	+1.8	+17.4	888.8325	1,275.709
				Reverse	−1,266.0	0.00								
				Mean	−1,266.0									
P. B. M. Shep; cap on pipe	T. B. M. 71	15	83.995	Direct	− 54.0	0.00	−3.11	+3.11	.00	5.1	+1.4	+17.4	890.0446	1,279.685
				Reverse	− 54.0	0.00								
				Mean	− 54.0									
T. B. M. 72	T. B. M. 71	1,339	85.319	Direct	−1,702.7	−1.00	−4.11	+4.11	.67	5.1	+1.8	+17.5	888.3949	....
				Reverse	−1,704.7	+1.00								
				Mean	−1,703.7									

TABLE NO. 3.—*Results of precise leveling, Aitkin, Minn., to Grand Rapids, Minn. (Blackberry station), 1902*—Continued.

Benchmark.	Determined from—	Length of stretch.	Distance from initial point.	Direction.	Difference of elevation.	Residuals =V.	Σ V		r	R	Rod correction.	Loop adjustment.	Elevation above Cairo datum.	
							Direct line.	Reverse line.	±	±				
		Meters.	*Km.*		*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Meters.*	*Feet.*
T. B. M. 73	T. B. M. 72	1,210	86.529	First direct	a+ 1.3		−3.30	+ 3.30	.54	5.2	+1.3	+17.7	388.4028	....
				First reverse	+ 9.2	−1.53								
				Second direct	+ 6.5	+1.17								
				Second reverse	+ 7.3	+0.37								
				Mean	+ 7.67									
T. B. M. 74	T. B. M. 73	1,358	87.887	Direct	+4,448.3	+1.60	−1.70	+1.70	1.07	5.3	+1.7	+17.8	392.8532	....
				Reverse	+4,451.5	−1.60								
				Mean	+4,449.90									
P. B. M. Split Hand; bolt in tile.	T. B. M. 74	18	87.905	Direct	−1,337.8	0.00	−1.70	+1.70	.00	5.3	+1.6	+17.8	391.5153	1,284.510
				Reverse	−1,337.8	0.00								
				Mean	−1,337.8									
P. B. M. Split Hand; cap on pipe.	T. B. M. 74	18	87.905	Direct	− 120.2	−0.05	−1.75	+1.75	.08	5.3	+1.7	+17.8	392.7329	1,288.505
				Reverse	− 120.3	+0.05								
				Mean	− 120.25									
T. B. M. 75	T. B. M. 74	1,922	89.809	Direct	−1,348.2	−0.30	−2.00	+2.00	.20	5.3	+1.6	+18.0	391.5098	....
				Reverse	−1,343.8	+0.30								
				Mean	−1,343.50									
T. B. M. 76	T. B. M. 75	1,424	91.233	Direct	+3,955.8	+0.20	−1.80	+1.80	.13	5.3	+2.0	+18.2	395.4664	....
				Reverse	+3,956.2	−0.20								
				Mean	+3,956.0									
T. B. M. 77	T. B. M. 76	1,693	92.926	Direct	−1,828.5	+0.40	−1.40	+1.40	.27	5.3	+1.8	+18.4	393.6383	....
				Reverse	−1,827.7	−0.40								
				Mean	−1,828.1									
P. B. M. Hamilton; bolt in tile.	T. B. M. 77	38	92.964	Direct	1,216.0	0.00	−1.40	+1.40	.00	5.3	+1.7	+18.4	392.4222	1,287.486
				Reverse	−1,216.0	0.00								
				Mean	−1,216.0									

P. B. M. Hamilton; cap on pipe.	T. B. M. 77	88	92.964	Direct	− 0.5	−0.15	−1.55	+1.55	.10	5.3	+1.8	+18.4	393.6876	1,291.473
				Reverse	− 0.8	+0.15								
				Mean	− 0.65									
T. B. M. 78	T. B. M. 77	1,452	94.378	Direct	+ 789.0	−1.00	−2.40	+2.40	.67	5.3	+1.9	+18.6	394.4266	....
				Reverse	+ 787.0	+1.00								
				Mean	+ 788.0									
T. B. M. 79	T. B. M. 78	1,652	96.030	Direct	−4,185.0	−0.35	−2.75	+2.75	.23	5.3	+1.4	+18.7	390.2408	....
				First reverse	a−4,195.3									
				Second reverse	−4,185.7	+0.35								
				Mean	−4,185.35									
T. B. M. 80	T. B. M. 79	2,820	98.850	Direct	+7,608.8	+0.35	−2.40	+2.40	.23	5.3	+2.2	+19.0	397.8511	....
				Reverse	+7,609.5	−0.35								
				Mean	+7,609 15									
P. B. M. Five Pines; bolt in tile.	T. B. M. 80	19	98.869	Direct	−1,133.7	−0.05	−2.45	+2.45	.08	5.3	+2.1	+19.0	396.7172	1,301.577
				Reverse	−1,133.8	+0.05								
				Mean	−1,133 75									
P. B. M. Five Pines; cap on pipe.	T. B. M. 80	19	98.869	Direct	+ 79.5	+0.10	−2.30	+2.30	.07	5.3	+2.2	+19.0	397.9307	1,306.559
				Reverse	+ 79.7	−0.10								
				Mean	+ 79.6									
T. B. M. 81	T. B. M. 80	1,559	100.409	Direct	− 766.2	−1.50	−3.90	+3.90	1.00	5.4	+2.1	+19.2	397.0635	....
				Reverse	− 769.2	+1.50								
				Mean	− 767.7									
T. B. M. 82	T. B. M. 81	1,645	102.054	Direct	+5,875.0	−0.10	−4.00	+4.00	.07	5.4	+2.7	+19.4	402.4592	....
				Reverse	+5,874.8	+0.10								
				Mean	+5,874.9									
P. B. M. Strawberry; bolt in tile.	T. B. M. 82	20	102.070	Direct	− 868.0	0.00	−4.00	+4.00	.00	5.4	+2.6	+19.4	401.5911	1,317.568
				Reverse	− 868.0	0.00								
				Mean	− 868.00									
P. B. M. Strawberry; cap on pipe.	T. B. M. 82	20	102.070	Direct	+ 347.3	−0.15	−4.15	+4.15	.10	5.4	+2.7	+19.4	402.8063	1,321.555
				Reverse	+ 347.0	+0.15								
				Mean	+ 347.15									

a Rejected.

TABLE NO. 3.—*Results of precise leveling, Aitkin, Minn., to Grand Rapids, Minn. (Blackberry station), 1902*—Continued.

Benchmark.	Determined from—	Length of stretch.	Distance from initial point.	Direction.	Difference of elevation.	Residuals =V.	Σ V		r	R	Rod correction.	Loop adjustment.	Elevation above Cairo datum.	
							Direct line.	Reverse line.	±	±				
		Meters.	*Km.*		*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Meters.*	*Feet.*
T. B. M. 83	T. B. M. 82	1,191	103.245	Direct Reverse	−14,831.5 −14,831.5	0.00 0.00	−4.00	+4.00	.00	5.4	+1.2	+19.5	387.6263	....
				Mean	−14,831.50									
T. B. M. 230 H (1900)	T. B. M. 83	2,099	105.344	Direct Reverse	+15,549.7 +15,550.0	+0.15 −0.15	−3.85	+3.85	.10	5.4	+2.7	+19.7	403.1778	1,322.774
				Mean	+15,549.85									
T. B. M. 229 H (1900)	T. B. M. 230 H (1900).	54	105.398	Direct Reverse	+ 213.0 + 213.7	+0.35 −0.35	−3.50	+3.50	.23	5.4	+2.8	+19.7	403.3913	1,323.474
				Mean	+ 213.35									
P. B. M. Blackberry (1900); bolt in tile.	T. B. M. 229 H (1900).	35	105.433	Direct First reverse Second direct Second reverse	−1,041.3 −1,042.7 −1,042.3 −1,041.7	−0.70 +0.70 +0.30 −0.30	−3.70	+3.70	.21	5.4	+2.7	+19.7	402.3492	1,320.055
				Mean	−1,042.0									
P. B. M. Blackberry (1900); cap on pipe.	T. B. M. 229 H (1900).	35	105.433	Direct Reverse	+ 169.8 + 170.2	+0.20 −0.20	−3.30	+3.30	.13	5.4	+2.8	+19.7	403.5613	1,324.082
				Mean	+ 170.0									

NOTES.—Main line 65.50 miles. Probable error per K= ± 0.53 mm. Side line 4.85 miles.

Methods of work are given in Report Chief of Engineers, 1899, page 3469.

The columns of the table are similar to those of the table given in supplement to the Report of Chief of Engineers, 1901, page 71, except column 13, which gives the loop adjustment that has been applied to the elevation of the benchmark in column 1. Columns 14 and 15 are the same as columns 13 and 14 of the report above quoted.

APPENDIX 1 C.

REPORT OF ASST. ENGINEER A. T. MORROW ON FIELD WORK OF LOW-WATER SURVEY, MISSISSIPPI RIVER, CAIRO TO CORONA LANDING, SEASON OF 1902.

ST. LOUIS, MO., *May 7, 1903.*

CAPTAIN: I have the honor to submit the following report on the work done on the low-water survey below the mouth of the Ohio River during the fall of 1902.

On October 1, I left St. Louis with steamer *Patrol* and the quarterboat *Illinois*, having on board surveyors and men to the number of about 70, and equipment for two surveying parties. I reached the mouth of the Ohio River the following day. The force and equipment were then divided into two parties, one under my charge remaining on the steamer *Patrol* and the other under charge of Asst. Engineer W. G. Comber being quartered on the *Illinois*.

On October 5 the quarterboat *Illinois* was towed to Caruthersville by the steamer *Mars*, which thereafter formed a part of the outfit of that party.

Work was begun at the mouth of the Ohio by the party under my charge on October 4, and by Mr. Comber's party 1 mile above Caruthersville on October 6. The number of assistants and men was increased until the parties numbered about 40 persons each.

The work of my party continued until November 29, when the work was closed on that begun by Mr. Comber near Caruthersville. I then proceeded to Memphis to take up the work at that point. The other party had by that time completed their field work to Corona landing. At this time high water set in and the work was discontinued by both parties, the last work being done by the party on the steamer *Patrol* on November 29 and by the other party on December 1.

The distance covered by the operations of the party on the steamer *Patrol* was 108 miles, and that covered by the operations of the two parties made a continuous stretch from the mouth of the Ohio River to Corona landing, a distance of 203 miles, which is about half the distance to the mouth of the Arkansas, to which point the work was to be extended. The part of the river left unfinished is probably more difficult than that already done, and I think the work undertaken was not quite half completed.

The character of the field work and the methods employed were similar to those of previous low-water surveys, except that sextants were dispensed with in locating soundings, and transits and stadia substituted therefor.

The stage of river was higher throughout than could be desired, but at no time were the bars entirely covered by water, and the progress of the work was not materially hindered. I see no good reason why the results obtained from these surveys should not serve well for purposes of comparison with previous surveys, some of which were likewise not made at low water.

After the parties were disbanded the regular emyloyees returned to this office and were soon thereafter assigned to other duties, so that but little progress has been made with the plats.

Respectfully submitted.

A. T. MORROW,
Assistant Engineer.

Capt. WM. B. LADUE,
Corps of Engineers, U. S. A.,
Secretary Mississippi River Commission.

APPENDIX 1 D.

REPORT OF ASST. ENGINEER KIVAS TULLY ON GAUGES, REDUCTION OF PHYSICAL DATA, AND OFFICE PUBLICATIONS.

ST. LOUIS, MO., *May 31, 1903.*

CAPTAIN: I have the honor to submit the following report upon the work pertaining to gauges, discharge observations, and office publications from June 1, 1902, to May 31, 1903.

GAUGES.

The gauges in charge of the secretary Mississippi River Commission comprise 37 regular gauges on the Mississippi River from St. Louis, Mo., to Fort Jackson, La., and its principal tributaries, 185 high-water gauges between Cairo and Head of the Passes, to supplement the regular gauges, and two tide gauges on the Gulf of Mexico. A gauge is also temporarily maintained on the Upper Mississippi River at Aitkin, Minn., during the continuance of field work of the general survey of the river in that vicinity. Twenty-one of the regular gauges were received by transfer from the United States Engineer Office at Vicksburg, Miss.. in February, 1901. All the other gauges were established by the Mississippi River Commission.

Detailed descriptions of all these gauges are to be found in the supplement to Report of the Chief of Engineers for 1902, pages 52 to 59, therefore only those of the gauges which have been reconstructed or changed since last year will be described in this report.

Two general inspections of all the gauges have been made during the year—one in the low-water and one in the high-water season. The low-water inspection of gauges on the main river from Head of the Passes to Memphis was made by a party on the steamer *Mississippi*, in charge of Junior Engineer George H. Wolbrecht, from the end of November, 1902, to January 5, 1903. Toward the end of this trip the river rose to a moderately high stage and the low-water sections of the gauges were, in consequence, not accessible to the inspector. The gauges at Lake Providence, Greenville, Arkansas City, and Mhoon Landing were inspected by party on steamer *Search*, in charge of Asst. Engineer F. B. Maltby, in October and November; and all gauges from Memphis to Cairo were inspected by this party or by the low-water survey parties in charge of Assistant Engineer Morrow, mainly during October and November, 1902.

All the gauges on the tributaries were inspected at low water in August and September, 1902. Another inspection of the gauges on the tributaries was begun in April and is nearly completed.

The high-water inspection of all gauges on the Mississippi River from Head of the Passes to Cairo is being made by a party on the steamer *Patrol* in charge of Junior Engineer E. L. Harman. This party also levels to high-water marks of the recent flood and otherwise completes the collection of data for the high-water profile of the main river.

At inspections the different footmarks of each gauge are connected by duplicate lines of levels with the bench marks in the vicinity, the gauges are repaired, the bulletin frames on which gauge readings are displayed to passing boats are repainted when necessary, and all left in good condition. The low-water inspection is obviously the most important, as at that time nearly all sections of the gauge and its bench marks are accessible.

The errors found in the gauges during the year were generally quite small, ranging from 0.01 to 0.2 foot. In most cases the corrections for these errors have been well determined and have been applied to the recorded readings. At Arkansas City and Mhoon Landing the temporary sections, used for brief periods, were largely in error, as described in detail below.

At St. Louis, Cairo, and Alexandria new gauges have been constructed. The gauge station at Belmont has been transferred across the river to Columbus, where it had been prior to June 8, 1884.

The following stations comprise those where new gauges were put in or where the gauges were materially disturbed during the year.

St. Louis, Mo. (U. S. Engineer gauge).—The old inclined gauge at this station had been in bad condition for some time. It was about thirty years old and consisted of railroad iron spiked to a wood stringer which was supported on piles driven about 8 feet apart. The rail had two sets of graduations cut into it, and both were in error, and the wood stringer was much decayed.

A new gauge was designed in this office and constructed under contract by the P. M. Bruner Granitoid Company of St. Louis. The new gauge is constructed of Portland cement concrete and 6-inch steel I beam, the latter being built into the concrete with the upper flange flush with top of concrete and surface of paved levee. The rail is in 30-foot lengths, jointed rigidly end to end with steel plates and bolts. Two tie-rods 1 inch square and about 4 feet long are built into concrete below each joint in rail. The old cypress piles, the tops of which were about 1 foot below surface, were found in a good state of preservation and were not disturbed. The cross section of the concrete is about 20 inches wide by 30 inches deep. It is built over the tops of the piles in a continuous length of about 195 feet; with the steel I beam this forms a single composite girder. Thus far not the slightest crack has been observed in the concrete. The exposed flange of the I beam has been painted with temporary graduations. The graduations will eventually be cut into the steel. This section will read from about 1 foot to 31 feet; when the river next falls to extreme low water the gauge will be extended downward to about 3 feet below the zero. This work was done about the middle of January of this year and at what proved to be the lowest stage of the season, the reading on January 14 being 4.55 feet. A vertical section of steel was also placed on the south wall of the harbor office, at foot of Market street, about 75 feet above the inclined section. This is graduated from 30 to 36 feet.

Cairo, Ill. (U. S. Engineer gauge).—A new gauge was constructed at this station by the U. S. Weather Bureau in October and November, 1902. The inclined section is of concrete, with steel beam built into it, and is somewhat similar to the gauge at St. Louis described above, the main difference being that the piling is omitted in the Cairo gauge. The tie-rods under rail joints were also omitted, and it was noticed that cracks appeared at the rail joints soon after the gauge was built. The gauge was graduated with paint only, early in December, and will be tested for settlement when the stage of the river falls sufficiently. In this gauge a 12-inch I beam was used. The inclined section extends from the 15-foot mark to the 50-foot mark. The cross section is 3 by 3 feet, with concrete spurs or piers, 3 feet cube, every 30 feet. A vertical section of steel bar was bolted to the upstream face of the concrete retaining wall just above the inclined section, and will read, when graduated, from 50 to 54 feet.

The new gauge is at the foot of Fourth street, on the site of the old timber gauge. The alignment and leveling for this gauge were done under direction of the secretary Mississippi River Commission.

Columbus, Ky. (Mississippi River Commission gauge).—A gauge was reestablished at this station October 18, 1902, to take the place of Belmont gauge, immediately across the river from Columbus. The change was made in accordance with a resolution of the Commission and as requested by the Pilots' Association. The readings on the Belmont gauge were continued until November 30, 1902, for comparison. The new gauge at Columbus was set at the same absolute elevation as the Belmont gauge and both gauges read practically the same. A new value, however, for its reference to Cairo datum was adopted. as described below.

The precise leveling between the bench marks in this vicinity shows discrepancies between present and former elevations. Compared with P. B. M. 10, on the Chalk Bluffs, about 3 miles below, the Columbus benches seem to have settled, P. B. M. 8 having settled 0.75 foot in about twenty years. As the hills back of Columbus seem to be washing down and making quite a fill in the vicinity of P. B. M.'s 8 and 9, it seems probable the original ground here has settled and the benches with it; therefore P. B. M. 10 has been adopted as standard and all other elevations have been adjusted to agree with it.

The adopted elevation of zero of Columbus gauge, derived by precise leveling in October, 1902, from P. B. M. 10, is 286.76 feet above the Cairo datum plane. The gauge is in vertical sections, attached to the piling of the railroad incline along the river near foot of Roan street. Columbus, Ky. The gauge bulletin, one of the new type, was erected at the foot of and about the center of Roan street.

Memphis, Tenn. (U. S. Engineer gauge).—This gauge is in vertical sections and was attached to timbers of the railway incline near the foot of Beal street. The gauge is difficult to maintain in this situation, and during the recent flood the incline was wrecked by a steamboat and the gauge with it. New sections were put up promptly by a party from the dredge fleet and the record has been continuous. An error of about 0.1 foot was found in one of the upper sections used before extreme high water; the proper correction has been made for it. The extreme high-water reading was taken on a section set reliably on a telegraph pole at foot of Beal street. This maximum reading was 40.10 feet and occurred March 20, 1903. The high water of 1897 read 37.66 feet on an old gauge at the elevator near the foot of Jefferson street. This is about three-quarters of a mile above the Beal street gauge. The two gauges are at the same elevation, but allowing 0.6 foot for slope of water surface between the two sites, which local authorities claimed for it in 1897, would make the high water of 1903 3.04 feet above that of 1897 at Memphis, Tenn.

Mhoon Landing, Miss. (Mississippi River Commission gauge).—A temporary section of the gage was 1 foot too low on October 12. The error had probably accumulated from the date it was set, September 9. The records were corrected on this assumption.

Arkansas City, Ark. (Mississippi River Commission gauge).—This gauge from 3 to 9 feet was disturbed by a steamboat November 12. and on November 18 it was found 1.17 feet too high. The readings for this period were corrected by means of a coordinate plat of this station and Greenville, Miss., and are printed with a question mark.

Alexandria, La. (Red River, U. S. Engineer gauge).—At the inspection September 9, 1902, the temporary sections of this gauge were found to be in error from

0.1 to 0.2 foot. The records have been corrected for these errors. A new gauge was made at this inspection, reading from −4 feet to 40 feet. The lower section extends from −4 to +4 feet and is a vertical staff gauge. The section from 4 to 40 feet is on the steel-plate web between the cylinder piers of the new bridge across the Red River at foot of Murray street, Alexandria, La. The gauge bench marks were destroyed when the court-house was rebuilt some time ago. P. B. M. 74 was used in leveling for the new gauge, but a wrong elevation was used for it in the field, and in consequence the new gauge was graduated to read 0.2 foot too high. The records have been corrected for this error, and at next low-water inspection the gauge will be graduated correctly.

A new type of gauge bulletin frame was designed in this office during the year, and three of these bulletins have been erected, one at each of the stations Cairo, Columbus, and St. Joseph, to replace others worn out or destroyed. The first two were made in August, 1902, and four more were made in April of this year. These last, one of which was erected at St. Joseph, possess some improvements in construction, mainly in detail, over the first two.

A drawing of the latest type of this bulletin is given on plate 3. The framework and plates are of steel. The four plate frames revolve on chilled steel pivots with hard brass collars; the plates are figured on both sides, and much of the time the necessary changes can be made by simply revolving the small frames. The construction is quite strong and substantial in order to withstand high winds. It is expected that the ease of operating this type will be conducive to perfect bulletin service.

The highest and lowest readings on all gauges in 1902, together with the elevation of gauge zeros and distances from Cairo, are given in Table No. 4. The daily reading of all gauges are platted on the office hydrographs for 1902; these have been traced on three sheets and blueprinted for distribution. The hydrograph of the main river from Cairo to Fort Jackson, June 1, 1902, to May 31, 1903, is given on plate 1. These hydrographs plainly show the effects of the breaks in levees or crevasses during the recent flood.

The inspections of high-water gauges have been made in connection with inspection of the regular gauges before described. Three new high-water gauges were established below Fort Jackson, La., at the December trip. These are designated, respectively, A, B, and C. A is on the right bank, about 4 miles above "The Jump;" B is at "The Jump," directly west of the old custom-house at that place; C is on the left bank, in front of the mess hall at quarantine station, about one-half mile above Cubitts Gap.

The maximum readings on all the high-water gauges for 1903, together with those of 1897 for comparison, are given in Table No. 5. The same, platted, forming a profile from Cairo to the Head of the Passes, are given on plate 2. In this connection attention might be invited to recommendations in previous reports to continue the releveling of the Commission northward from Fort Adams, Miss., until the Cairo datum plane can be reliably referred to adopted mean Gulf level at Biloxi, Miss.

The automatic tide gauges, one at Biloxi, Miss., and one at East Bay, La., have been maintained during the year, and a continuous record has been obtained for both stations.

These gauges were inspected in October and December, 1902. At the December inspection the staff gauges were connected by precise leveling with the permanent bench marks. The brick and cement structure, designated "Biloxi," in the town of Biloxi, was also tested by leveling in December, and the bronze bolt in cap was set at precisely 25 feet above adopted mean Gulf level. A new tile and pipe bench was set near P. B. M. 19A and designated "P. B. M. Reference." Its elevations in meters above mean Gulf level are: Bolt in tile, 0.77080; cap on pipe, 1.98425.

The East Bay staff gauge was found to be 53 millimeters (0.174 foot) too low. It was presumed that the staff had settled that amount since the previous precise leveling in 1898, and the records have been corrected accordingly. P. B. M.'s I, D, and X were connected with and P. B. M. I taken as standard, as it is undoubtedly the most stable bench mark in the vicinity. D was 4.15 millimeters low and X was 10 millimeters low. (See Report Chief of Engineers for 1900, pages 4680 and 4681, for elevations of these gauges and bench marks above adopted mean Gulf level.)

The reduction of the tidal records has been brought to the end of 1902. The mean readings for 1902, from the preliminary reduction, are: Biloxi, +0.051 foot, and East Bay, +0.048 foot, referred to the finally adopted mean Gulf level at Biloxi. Owing to the break in the records caused by the destruction of the tide gauges in August, 1901, at time of the severe storm on the Gulf, it is deemed best to await completion of records of the present calendar year before making the final adjustment and presenting the results for publication.

The self-recording time device on the Biloxi automatic gauge described in last year's report and shown on plate 3, supplement to Report Chief of Engineers for 1902, has proved very satisfactory and much facilitates the reduction of the tide rolls.

DISCHARGE OBSERVATIONS.

High water discharge measurements during the recent flood have been made at all the regular discharge stations on the Mississippi River below Cairo, and on the lower tributaries where the stage reached the prescribed limits. In addition some bayou and crevasse measurements were made. The discharge observations were made by two separate parties under direction of the Secretary, as follows: The party on the steamer *Venus*, in charge of Asst. Engineer William Gerig, measured the discharge of the Mississippi River at Columbus, Ky., and Helena, Ark., and the discharge of Yazoo River below Haines Bluff, that of the Red River at Alexandria, La., and of the Black River at Jonesville, La.; the party on the steamer *Patrol*, in charge of Junior Engineer E. L. Harman, measured the discharge of the Mississippi River at Arkansas City and Chicot City, Ark., Vicksburg, Miss., Red River Landing, La., and Carrollton, La., and of the Atchafalaya River at Simmesport, La., also the discharge of Bayou Lafourche and approximately that of the Hymelia crevasse.

The discharge observations were made at the maximum stage at all stations on the main river except at Carrollton, La., where discharge was measured at a stage of about 0.3 foot below the maximum. The stage at Alexandria, La., was also about 0.3 foot below the maximum when discharge was measured.

The observations were made in accordance with the standard instructions of the commission. The velocities were measured mainly with the Haskell current meter run for five minutes at each velocity station at six-tenths depth immersion; where the immersion was less, corrections have been applied, as stated in notes accompanying the tabulated results. Price meter No. 40 was also used for a time by the party on the steamer *Patrol*. The Haskell meters had been rated at the settling basins of the St. Louis waterworks before the field season, and these meters, together with the Price meter, were again rated at the conclusion of the discharge work.

The locations of velocity stations and soundings were determined by observers on shore with transit or by sextant angles from the steamboat. The steamboat was kept on the discharge range by means of fixed signals on shore in line with the range. Velocities were also measured with double floats, the lower float being at mid depth. The soundings were made from the steamboat, the boat going above the range and drifting back over the range for each sounding. These soundings were made with great care and the lead line tested at the conclusion of each day's work. The soundings have been corrected for any errors in lead line. The field notes of all these discharge observations are now being reduced in this office, following the usual exact methods. The results, with special notes for each station, will be given in table No. 7. The results of the meter ratings will be given in table No. 7*a*.

On July 18–19, 1902, the discharge of the Mississippi River was measured at foot of Arsenal street, St. Louis, Mo., at a stage of 25.39 feet on the St. Louis gauge. This was done in connection with the deep waterway survey. A party from Major Casey's office was at the same time measuring discharge by means of rod floats immersed to about nine-tenths depth, and advantage was taken of the opportunity to compare results of this methed with those of the commission methods of current meters and double floats. The experiment was also tried of using two meters simultaneously, at the usual six-tenths depth immersion, on either side of a skiff and about 8 feet apart. Each meter had separate battery and register. They had previously been rated together in the same relative position.

Double floats of the usual form were also used, the lower float being at mid-depth, and for some stations at six-tenths depth. The observations were made by the three methods as nearly as practicable at the same time. A decked barge was anchored at each velocity station and from this the observations were made, the skiff carrying the meters was attached to the barge by a line and dropped down to the discharge range. A steamboat was in use as tender and the cross-section was sounded from the steamboat at conclusion of velocity observations. Great care was used in timing the floats. Two observers, each with a stop watch, kept time independently of each other as a check.

The velocity observed with rods was presumably reduced to mean by Francis's formula, but this correction being small, its neglect would not have materially affected the results of the comparison.

The two meters agreed very closely except at two stations, and at these stations an examination showed that this was due to an imperfect contact between the carbons in the Partz battery. The rod floats and meters agreed very closely; the double floats differed materially from both the other methods, giving usually higher velocities and showing much larger fluctuations.

The rod floats operated in this way are unquestionably a good method, but are conceded to be impracticable for use at the great depths existing in the lower Mississippi at high water; and as they, at even moderate depths, involve more labor than do the current meters, the latter, if they give equally good results, are to be preferred for that reason. While this very limited experiment can not be regarded as conclusive, it tends to throw some doubt on the reliability of the double-float method.

A chronograph, originally made for use at Burlington, Iowa, has been obtained with the purpose of rating and operating several meters simultaneously, and will be used when some more meters expected from the district officers are received.

MISCELLANEOUS.

The daily stages of the Mississippi River and its principal tributaries for the calendar year 1902 has been prepared and is being printed. This is a pamphlet of about 125 pages, and contains, besides the daily gauge readings at 57 stations, descriptions and elevations of each gauge and its bench marks.

The monthly reports of operations, and proceedings of the commission for its eighty-sixth to eighty-eighth sessions have been printed. The scientific records and drawings of the secretary's office have been indexed and cared for.

Mr. E. J. Thomas, junior engineer, and Messrs. E. E. Whitehead, K. N. G. Saurbrey, recorders, have assisted in the office work during the year while not engaged in field duty; their services have been most efficient and faithful.

Respectfully submitted.

KIVAS TULLY,
Assistant Engineer.

Capt. WM. B. LADUE,
Corps of Engineers, U. S. A.,
Secretary Mississippi River Commission.

TABLE NO. 4.—*Highest and lowest gauge readings of 1902.*

MISSISSIPPI RIVER.

Station.	Distance from Cairo.	Elevation of gauge zero above Cairo datum plane.	Elevation of gauge zero above mean Gulf level.	Highest.					Lowest.				
				Prior to 1902.		1902.		Difference compared with previous highest.	Prior to 1902.		1902.		Difference compared with previous lowest.
				Date.	Gauge reading.	Date.	Gauge reading.		Date.	Gauge reading.	Date.	Gauge reading.	
	Miles. Above.	*Feet.*	*Feet.*		*Feet.*		*Feet.*	*Feet.*		*Feet.*		*Feet.*	*Feet.*
Aitkin, Minn	1,086	1,206.76				May 27, 28	18.05				July 29	1.8	
Hastings, Minn	850	690.79		Apr. 30, 1881	18	June 10	8.1	− 9.90	Nov. 23, 1892	−0.70	Apr. 23-25	.8	+ 1.50
Winona, Minn	760	660.34		June 18, 1880	16.87	Nov. 21, 22	7.2	− 9.67	Dec. 30, 1889	−1.33	Aug. 29	1.7	+ 3.03
Prairie du Chien, Wis	668	625.59		June 22, 1880	21.30	May 24	10.8	−10.50	Nov. 26, 1898	.1	Aug. 31, Sept. 1	.9	+ 0.80
Rock Island, Ill	510.7	562.37		June 27, 1892	19.4	May 26, 27	10.4	− 9	Jan. 5, 6, 1890	− .9	Dec. 12	1.6	+ 2.50
Burlington, Iowa	427.6	531.25		May 18, 19, 1888; June 30, 1892.	17.6	July 21	10.8	− 6.80	Dec. 4, 5, 1895	−1.1	Jan. 27, Feb. 7	0.6	+ 1.70
Nashville, Iowa	393.6	516.86		May 17, 18, 1888	12	July 21, 22	7.5	− 4.50	Jan. 7, 1890	− .5	Jan. 22	.6	+ 1.10
Hannibal, Mo	329.4	469.60		May 17, 1888	21.58	July 23	16.6	− 4.98	Jan. 9, 1890	−1.75	Jan. 11, 12	1.2	+ 2.95
Grafton, Ill	233	424.09		May 18, 1892	25.73	July 23	20.4	− 5.33	Dec. 9, 1895	− .9	Jan. 29	.8	+ 1.70
St. Louis, Mo	190.8	400.23		May 19, 1892	[a]35.95	do	26.89	− 9.06	Jan. 2, 1900	−2.52	Jan. 30	−1.10	+ 1.42
Chester, Ill	115.5	361.30		May 21, 1892	31.2	July 27	22.8	− 8.40	Jan. 3, 1900	−4.1	Jan. 30, 31	−1.4	+ 2.70
Cape Girardeau, Mo	54.5	324.97		Apr. 12, 13, 1897	31.6	July 26-28	26.3	− 5.30	Dec. 26, 27, 1897	1.0	Feb. 1	.8	− .20
Grays Point, Mo	48	321.28		May 22, 1892	35								
Cairo, Ill	0	290.84		Feb. 27, 1883	52.17	Mar. 17	42.14	−10.03	Dec. 31, 1880	.95	Sept. 26	7.25	+ 6.30
	Below.												
Columbus, Ky. (Belmont, Mo.).	21.6	286.76		Feb. 26, 1883	45.58	do	38.60	− 6.98	Nov. 6-8, 1895	.05	do	7.50	+ 7.45
Morrison Landing, Mo.[b]	69	275.80		Feb. 24, 1884	41.50				Nov. 11-14, 1879	− .17			
New Madrid, Mo	70.3	275.72		Mar. 29, 1897	40.27	Mar. 18	33.24	− 7.03	Nov. 6-8, 1895	.55	Sept. 27	6.85	+ 6.30
Cottonwood Point, Mo	122.5	250.67		Mar. 21-23, 1897	39.35	Mar. 19	32.8	− 6.55	Nov. 5-8, 1895	−3.35	do	3.5	+ 6.85
Fulton, Tenn	175.4	228.55		Apr. 10, 1898	38.30	Mar. 20	29.55	− 8.75	Nov. 7, 8, 1895	.16	Sept. 28	4.30	+ 4.14
Memphis, Tenn	230	203.97		Mar. 20, 1897	37.66	Mar. 21	30.90	− 6.76	Nov. 6-9, 1895	−2.65	Sept. 29	2.90	+ 5.55
Mhoon Landing, Miss	276.3	181.48		Apr. 4, 1897	41.60	Mar. 22	34.3	− 7.30	Nov. 6-11, 1895	−7.80	do	1.9	+ 9.70
Helena, Ark	306.5	161.98		do	51.75	Mar. 23, 24	39.58	−12.17	Nov. 8, 9, 1895	−3.00	do	6.38	+ 9.38
Sunflower Landing, Miss.	352.7	147.08		Mar. 27, 1897	47.17	Mar. 24	38.75	− 8.42	Nov. 12-14, 1895	−1.50	Sept. 30	7.20	+ 8.70
Mouth White River, Ark.	393.2	128.73		Mar. 29, 1897	52.42	Mar. 28	43.30	− 9.12	Dec. 28, 1872	.00	do	9.75	+ 9.75
Arkansas City, Ark	438.3	116.44		do	51.9	Mar. 29	41.4	−10.50	Nov. 9, 10, 1895	−3.6	Oct. 1	6.8	+10.40
Greenville, Miss	478.3	108		do	46.75	do	36.05	−10.70	Nov. 10, 11, 1895	−2.55	do	6	+ 8.55
Lake Providence, La	542.3	89.62		Mar. 30, 1897	44.54	Mar. 30, Apr. 16, 17.	34.95	− 9.59	Nov. 17, 1895	−5.30	Oct. 2	5.30	+10.60

[a] High water of June 28, 1844, would read 41.4 feet.

[b] Gauge transferred to New Madrid in 1898.

TABLE NO. 4.—*Highest and lowest gauge readings of 1902*—Continued.

MISSISSIPPI RIVER—Continued.

Station.	Distance from Cairo.	Elevation of gauge zero above Cairo datum plane.	Elevation of gauge zero above mean Gulf level.	Highest.					Lowest.				
				Prior to 1902.		1902.		Difference compared with previous highest.	Prior to 1902.		1902.		Difference compared with previous lowest.
				Date.	Gauge reading.	Date.	Gauge reading.		Date.	Gauge reading.	Date.	Gauge reading.	
	Miles. Below.	*Feet.*	*Feet.*		*Feet.*		*Feet.*	*Feet.*		*Feet.*		*Feet.*	*Feet.*
Vicksburg, Miss	599.3	66.04	....	Apr. 16, 1897	52.48	Apr. 17	41.22	−11.26	Nov. 13, 14, 1895.	−6.5	Oct. 2	4.73	+11.23
St. Joseph, La	648.3	52.74	....	Apr. 17, 1897	47.85	Apr. 18	37.15	−10.70	Nov. 13, 1895	−9.3	Oct. 3	1	+10.30
Natchez, Miss	700.3	36.80	....	May 2, 1897	49.82	do	40.25	− 9.57	Nov. 13-15, 1895.	− .85	do	7.50	+ 8.35
Red River Landing, La.	765.3	....	3.57	May 14, 15, 1897.	50.20	Apr. 18-20	38.80	−11.40	Nov. 14, 1895	− .60	Oct. 1	7.80	+ 8.40
Bayou Sara, La	799.8	....	4.15	May 13-15, 1897.	43.7	do	31.7	−12	Nov. 16, 1895	−2.7	do	2.6	+ 5.30
Baton Rouge, La	833.3	....	− .42	do	40.65	Apr. 18, 19	29.40	−11.25	Nov. 14, 1894	.45	do	4.10	+ 3.65
Plaquemine, La	854.1	....	.44	May 13-17, 1897.	36.25	Apr. 19, 20	25.6	−10.65	do	− .94	Oct. 1, 2	2.5	+ 3.44
Donaldsonville, La	885.4	....	−1.01	May 13, 1897	32.75	Apr. 19	23.30	− 9.40	Nov. 11, 1894	1.00	Nov. 23	3.05	+ 2.05
College Point, La	904.5	....	.29	May 15, 1897	27.95	do	19.50	− 8.45	Nov. 14, 1894	− .91	Oct. 4, Nov. 18.	1.25	+ 2.16
Carrollton, La	957	....	− .13	May 13, 1897	19.17	Apr. 14, 18, 21.	13.35	− 5.82	Dec. 27, 1872	−1.60	Nov. 17	1.10	+ 2.70
Fort Jackson, La	1,039	....	−1.68	Apr. 22, 23, 29; May 14, 16, 1897	7.2	Apr. 14	6.85	− 0.85	Dec. 7, 1893; Nov. 12, 14, 1894.	.3	Feb. 3	1.40	+ 1.10

TABLE NO. 4.—*Highest and lowest gauge readings of 1902*—Continued.

TRIBUTARIES OF MISSISSIPPI RIVER AND THE ATCHAFALAYA.

River.	Station.	Approximate distance of station from—	Elevation of gauge zero above Cairo datum plane.	Elevation of gauge zero above mean Gulf level.	Highest.					Lowest.				
					Prior to 1902.		1902.		Difference compared with previous highest.	Prior to 1902.		1902.		Difference compared with previous lowest.
					Date.	Gauge reading.	Date.	Gauge reading.		Date.	Gauge reading.	Date.	Gauge reading.	
		Miles.	*Feet.*	*Feet.*		*Feet.*		*Feet.*	*Feet.*		*Feet.*		*Feet.*	*Feet.*
Arkansas	Little Rock, Ark	Mouth ...176	241.53		May 21, 1892	31.20	Dec. 19	20.60	−10.60	Nov. 20, 1887	[a]2.00	Jan. 16-17	2.70	+0.70
Arkansas [b]	Pine Bluff, Ark	Mouth ...110	200.34		May 22, 1892	30.50				Nov. 20-23, 1887	− .40			
Atchafalaya	Barbre Landing, La.	Head ... 0		3.91	May 13-14, 1897	50.95	Apr. 21	37.38	−13.57	Oct. 26, 1897	− 1.77	Sept. 30	7.10	+8.87
Atchafalaya [b]	Simmesport, La	Head ... 4	24.17		May, 1897	49.22				Nov. 8, 1891	− 1.60			
Atchafalaya	West Melville, La	Head ... 27		−0.1	Mar. 31, 1882	37	Apr. 19-22	32.9	− 4.10	Nov. 12-13, 1894	1.0	Oct. 1	9.2	+8.2
Cumberland	Nashville, Tenn	Cairo ...244			Jan. 22, 1882	55.30	Apr. 4	46.20	− 9.10	Oct. 15-16, 1878	− .40	Sept. 23	.93	+1.33
Illinois	Peoria, Ill	Mouth ...160	454.66		May 9, 1892	21.9	July 22	21	− .9	Oct. 7, 1890	2.6	Jan. 23-27	6.8	+4.2
Illinois [b]	Beardstown, Ill	Mouth ... 86	444.29		1882	21.3				Aug. 11-12, 1887	.00			
Missouri [b]	Coles Creek, Mo	Mouth ...107	433.97		May 15, 1892	96.76				Dec. 24, 1897	70.7			
Missouri	Herman, Mo	Mouth ...103	502.17		do	[c]24.8	July	18	− 6.8	Dec. 22, 1897	− .6	Jan. 29	1.7	+2.3
Ohio	Cincinnati, Ohio	Mouth ...504	447.62		Feb. 14, 1884	71.06	Mar. 5	50.90	−20.10	Sept. 18, 1881	1.92	Sept. 24-25	3.90	+1.98
Ohio	Louisville (upper), Ky.	Mouth ...364	419.76		Feb. 16, 1884	46.60	Mar. 9	24.80	−21.80	Sept. 10-14, 18-22, 1881; Nov. 14-16, 1895.	1.70	Sept. 7-13	2.70	+1
Ohio	Louisville (lower), Ky.	Mouth ...364	392.85		do	72	do	50.40	−21.60	Oct. 17-18, 1872.	1.60	Sept. 27-30	3.80	+1.70
Ohio	Paducah, Ky	Mouth ... 45	300.46		Feb. 23, 1884	54.25	Mar. 15-16	39.7	−14.55	Oct. 30-Nov. 4, 1895.	− .7	Sept. 17-18, 23-26.	1.4	+2.1
Ohio	Cairo, Ill	Mouth ... 1	290.84		Feb. 27, 1883	52.17	Mar. 17	42.14	−10.03	Dec. 24, 1871	− 1	Sept. 26	7.25	+8.25
Ouachita	Camden, Ark	Mouth Red River ..325		71.10	May 12, 1882	46	Dec. 1	36.20	− 9.80	Aug. 29-30, 1887	1.80	July 23-26	3.95	+2.15
Ouachita	Monroe, La	Mouth Red River ..175		30.97	1882	48.60	Apr. 27-28	35.1	−13.50	Sept.-Nov., 1897 and 1899.	0.0	Sept. 11-12	1.3	+1.3
Red	Fulton, Ark	Mouth ...508		224.48	July 17, 1876	35.75	Dec. 1	32.20	− 3.55	Oct. 20-22, 1896.	.10	Jan. 22-23	3.20	+3.20

[a] Low water of 1879, adopted by the U. S. Engineer office at Little Rock, Ark., reads 2.01 feet on present gauge.
[b] Discontinued.
[c] H. W. of June, 1844, would read 35.6 feet.

TABLE No. 4.—*Highest and lowest gauge readings of 1902*—Continued.

TRIBUTARIES OF MISSISSIPPI RIVER AND THE ATCHAFALAYA—Continued.

River.	Station.	Approximate distance of station from—	Elevation of gauge zero above Cairo datum plane.	Elevation of gauge zero above mean Gulf level.	Highest. Prior to 1902. Date.	Highest. Prior to 1902. Gauge reading.	Highest. 1902. Date.	Highest. 1902. Gauge reading.	Highest. Difference compared with previous highest.	Lowest. Prior to 1902. Date.	Lowest. Prior to 1902. Gauge reading.	Lowest. 1902. Date.	Lowest. 1902. Gauge reading.	Lowest. Difference compared with previous lowest.
		Miles.	*Feet.*	*Feet.*		*Feet.*		*Feet.*	*Feet.*		*Feet.*		*Feet.*	*Feet.*
Red[a]	Garland, Ark	Mouth ...450		203.16	Mar. 24, 1894	28.50				Sept. 22–25, 1896	− .20			
Red	Shreveport, La	Mouth ...320		140.99	May 28, 1892	35.70	Dec. 15–16	34.10	− 1.60	Dec. 2–4, 1894	− 5.50	Jan. 25–26	−1	+4.50
Red	Alexandria, La	Mouth ...110		44.18	June 12–13, 1892.	38.25	Dec. 24	32.20	− 6.05	Sept. 29, 1881	− 3.7	Jan. 25	−2.15	+1.55
St. Francis	Bridge, St. Louis, Iron Mountain and Southern Ry.	Mouth ...194			Apr. 4–6, 1897	41.6	Dec. 31	16.80	−24.8	Nov. 3–11, 1901	− .05	Sept. 13–22	0.0	+ .05
St. Francis[a]	Wittsburg, Ark	Mouth ...180			Apr. 28, 1886	42.02				Oct. 27–31, Nov. 10–14, 1892.	− 3.60			
Tennessee	Chattanooga, Tenn	Cairo.....495	651.90		Mar. 1, 1875	54	Jan. 2	40.80	−13.20	Sept. 11–14, 1881, and 19, 1883.	.00	Sept. 2–3, Oct. 30–31.	1.20	+1.20
Tennessee	Florence, Ala	Cairo.....300	418.03		Mar. 19, 1897	32.20	Mar. 29	21.70	−10.50	Oct., 1872, Sept. 18, 1878.	− .76	Nov. 4	− .40	+ .36
Wabash	Mount Carmel, Ill	Cairo.....190	397.86		Aug. 7, 1875	28.3	Dec. 25	17	−11.3	Nov. 7–23, 1895	− .2	Sept. 25–26	1	+1.2
White	Jacksonport, Ark	Mouth ...360			Mar. 14, 1890	33.35	Dec. 19	25.55	− 7.80	Dec. 24, 1872	− 1.10	Aug. 21	− .45	+ .65
White	Clarendon, Ark	Mouth ...134	158.9		Mar. 20, 1890	36.63	Dec. 30	28.30	− 8.33	Nov. 22, 1887	4.07	Aug. 28, Nov. 6–8.	5.40	+1.33
Yazoo	Yazoo City, Miss	Mouth ... 65	93.34		1882	36.50	Apr. 21–22	26.6	− 9.90	1875	− 4.30	Oct. 30–31, Nov. 1–24.	−2.1	+2.20

[a] Discontinued.

TABLE NO. 5.—*High water, Mississippi River, Cairo to Head of Passes, 1903.*

Number of gauge.	Distance from Cairo.	Date of highest reading in 1903.	Elevation above Memphis datum.			Difference between 1897 and 1903.	Regular gauge readings.		
			1903.	1897.	1898.		1903.	Previous highest.	
	Miles.		*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Yrs.*	*Feet.*
Cairo	0	Mar. 15-17	328.3	329.4	327.5	−1.1	50.57	1883	52.17
182	4.4	Mar. 17, 18	326.2	327.4		−1.2			
180	12.5	Mar. 17	323.7	324.3		−0.6			
179	17.8	do	320.8	321.4		−0.6			
Columbus	21.3	do	318.1	318.7	317.7	−0.6	44.50	1883	45.58
178	27.5		316.2	316.5		−0.3			
177	33.5	Mar. 16	314.0	314.2		0.2			
176	38.5	Mar. 17	311.6	312.0	310.5	−0.4			
175	44.3		309.4	309.7	308.4	−0.3			
174	49.8	Mar. 16	307.4	308.0	306.5	−0.6			
173	54.0		306.5	306.9	305.4	−0.4			
172	59.5	Mar. 16, 17	306.0	306.4	304.7	−0.4			
171	64.5			304.9					
New Madrid	70.3	Mar. 17	302.1	302.9	301.0	−0.8	30.54		
169	78.9	Mar. 16-18	297.5	298.3		−0.8			
168	84.8	Mar. 17	295.6	296.3	294.8	−0.7			
167	89.5		292.3	293.1		0.8			
166	95.0		289.4	289.9	288.4	−0.5			
165	99.3	Mar. 18	287.8	288.0	286.6	−0.2			
164	104.1		286.2	286.4		0.2			
163	109.3	Mar. 18	283.4	283.3	282.3	+0.1			
162	113.5		281.4	281.2		+0.2			
161	118.5	Mar. 19	279.1	278.8	277.9	+0.3			
Cottonwood Point	123.0	do	277.6	276.8	276.1	+0.7	40.09	1897	39.35
160	127.4		276.3	275.7	274.8	+0.6			
159	130.5		274.9	274.0		+0.9			
158	135.0	Mar. 20	273.7	273.0		+0.7			
157	140.0		271.8	270.8	270.2	+1.0			
156	152.8		265.1	264.0		+1.1			
154	158.3	Mar. 20	262.6	261.4		+1.2			
153	161.8	Mar. 18, 19	261.6	260.2	259.8	+1.4			
152	167.5		?260.0	258.3	258.4	? +1.6			
151	172.8		?257.2	254.8		? +2.4			
Fulton	175.4	Mar. 19	255.6	252.9	253.7	+2.7	40.15	1898	38.30
150	180.1	do	253.9	251.2	251.5	+2.7			
149	186.3		250.4	247.5	248.1	+2.9			
148	192.6	Mar. 19	247.8	245.7	246.0	+2.1			
147	197.3	do	246.8	243.8		+3.0			
146	203.3		243.8	240.1	240.7	+3.7			
145	208.0		243.0?	238.4	238.7	+4.6?			
144	212.8		238.8	235.5		+3.3			
143	220.4		236.7	233.3	233.7	+3.4			
142	225.5		232.7	229.3	229.4	+3.4			
Memphis	230.0	Mar. 20	231.0	[a] 227.9	228.4	+3.1	40.12	1897	37.66
141	235.0	Mar. 16	228.4	225.1		+3.3			
140	239.6	Mar. 19	225.6	222.9		+2.7			
139a	245.2	Mar. 20-22	224.4	221.0		+3.4			
138	249.5	Mar. 24	221.6	218.2	217.8	+3.4			
137	256.3	Mar. 28	217.5	215.4	214.6	+2.1			
136	261.2	Mar. 23	215.0	213.6	212.3	+1.4			
135	266.8	Mar. 22-24	213.2	211.8	210.1	+1.4			
134	271.0	Mar. 6	211.0	210.8		+0.2			
Mhoon Landing	276.3	Mar. 24, 25	210.2	210.0	207.4	+0.2	41.80	1897	41.60
133	280.5	Mar. 25	209.2	209.5	207.1	−0.3			
132	284.2	Mar. 18	206.6	207.6	204.6	−1.0			
131	289.5		205.6	206.6	203.4	−1.0			
130	293.6		204.0	205.0	201.9	−1.0			
129	297.6		203.7	204.6	201.2	−0.9			
128	301.5	Mar. 26	202.0	203.2	200.1	−1.2			
Helena	306.5	Mar. 26, 27	199.8	200.6	198.0	−0.8	51.00	1897	51.75
127	312.5	Mar. 27	197.2	197.5	195.2	−0.3			
126	317.8	Mar. 26	195.3	195.2	193.3	+0.1			
125	323.5	Mar. 27	193.2	193.2	191.1	0.0			
124	329.3	Mar 29	191.2	190.9	188.9	+0.3			
123	334.5	Mar. 27	189.5	189.4	187.3	+0.1			
122	339.0	Mar. 27, 28	186.6	185.8	184.3	+0.8			
121	342.5	Mar. 29	185.5	184.8	183.4	+0.7			
120	346.8	Mar. 30	184.0	183.1	182.1	+0.9			
Sunflower Landing	352.7	Mar. 27, 28	182.0	181.1	180.0	+0.9	48.00	1897	47.17
119	357.0	do	180.6	179.5	178.4	+1.1			
118	362.0		179.4	178.5	177.3	+0.9			
117	366.7	Mar. 29	177.8	176.5	175.6	+1.3			
116	371.8		176.5	175.1	174.3	+1.4			
115	378.0	Mar. 28	173.8	172.5	171.5	+1.3			
114	383.6	do	171.7	170.4	168.8	+1.3			

[a] 1897 corrected for slope.

TABLE No. 5.—*High water, Mississippi River, Cairo to Head of Passes, 1903*—Continued.

Number of gauge.	Distance from Cairo.	Date of highest reading in 1903.	Elevation above Memphis datum.			Difference between 1897 and 1903	Regular gauge readings.		
			1903.	1897.	1898.		1903.	Previous highest.	
	Miles.		*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Yrs.*	*Feet.*
113	389.6	Mar. 29	171.0	169.3	168.0	+1.7			
Mouth of White River	393.2	Mar. 27-29	169.3	168.0	166.7	+1.3	53.70	1897	52.42
112	398.8	Mar. 27, 28	167.6	166.2	165.0	+1.4			
111a	401.7		166.6	165.3	164.0	+1.3			
110	408.0		164.8	164.0	162.7	+0.8			
109a	412.0	Mar. 27, 28	163.9	162.9	161.5	+1.0			
108	416.8	Mar. 29	163.3	162.4	161.1	+0.9			
107	421.7	Mar. 28	162.3	160.7	159.2	+1.6			
106	427.0	Mar. 27, 28	160.6	159.7	158.2	+0.9			
105	432.4	do	157.8	157.0	156.0	+0.8			
Arkansas City	438.3	do	156.3	155.2	154.5	+1.1	52.96	1897	51.9
104	444.8		153.5	152.4	151.5	+1.1			
103	449.5		152.7	151.6	150.8	+1.1			
102	454.0	Mar. 27	149.7	148.6		+1.1			
101a	459.0	do	149.4	148.2	147.3	+1.2			
100	463.7	do	148.6	147.3	146.7	+1.3			
99	467.0	do	147.8	147.0	146.0	+0.8			
98	473.4	do	145.7	144.0	143.4	+1.7			
Greenville	478.3	do	144.0	141.6	141.0	+2.4	49.10	1897	43.75
97	482.6	do	143.3	140.5	140.3	+2.8			
96	486.7	do	142.1	139.7		+2.4			
95a	489.8	do	141.4	138.6		+2.8			
94	495.3	do	139.5	136.9		+2.6			
93a	500.9	do	137.3	134.8		+2.5			
92	505.5	do	135.8	133.8		+2.0			
91a	510.7	do	133.0	131.2		+1.8			
90a	517.0	do	131.0	129.0		+2.0			
89	522.8	Mar. 29	129.9	127.6		+2.3			
88	525.8	Mar. 27	128.0	125.8	125.6	+2.2			
87	531.5	do	126.2	123.8		+2.4			
86	537.5	do	124.2	122.3		+1.9			
Lake Providence	542.3	do	123.0	121.0	120.8	+2.0	46.48	1897	44.54
85	546.5		122.4	119.9		+2.5			
84	552.3		120.7	117.9		+2.8			
83	556.5	Mar. 27	118.6	116.4		+2.2			
82	561.3		117.1	115.4		+1.7			
81	567.8	Mar. 27	113.6	112.2	111.1	+1.4			
80	573.8	do	112.0	110.9		+1.1			
79	578.0	do	110.6	109.8		+0.8			
78a	583.3	do	109.5	109.2		+0.3			
77	588.7	Mar. 26	107.6	108.0		−0.4			
76	593.4		106.3	107.0		−0.7			
Vicksburg	599.3	Mar. 27, 28	104.7	105.4	102.3	−0.7	51.80	1897	52.48
75	602.6	Mar	103.2	103.2		0.0			
74	607.5	Mar. 28	101.9	102.6	100.3	−0.7			
73	612.7		99.3	99.7	97.3	−0.4			
72	617.3		97.2	97.6	94.8	−0.4			
70	627.8		94.5	94.7	92.0	−0.2			
69	632.9		92.3	92.4	89.2	−0.1			
68	638.3		90.2	90.1	87.5	+0.1			
67	642.8	Mar. 28	88.9	88.7	86.3	+0.2			
St. Joseph	648.3	do	87.7	87.5	84.7	+0.2	48.10	1897	47.85
66	655.3	do	85.0	84.4	81.6	+0.6			
65	659.8	do	83.8	83.4	80.0	+0.4			
64	663.8		82.9	82.6	79.4	+0.3			
63	680.8	Mar. 27, 28	81.8	81.6	78.4	+0.2			
62	685.5	Mar. 28, 29	80.7	79.9	77.4	+0.8			
61	691.5	Mar. 28	78.5	77.5	74.9	+1.0			
60	694.0	Mar. 29	76.8	76.2	73.4	+0.6			
Natchez	700.3	Mar. 28, 30, Apr. 2.	74.1	73.6	71.2	+0.5	50.35	1897	49.82
59	705.5		72.9	72.4	69.8	+0.5			
58	711.3	Mar. 29	72.2	71.5	68.9	+0.7			
57	716.0		71.6	70.8	68.1	+0.8			
56	720.5		69.8	69.3	66.5	+0.5			
55	725.2	Mar. 28	68.7	68.0	65.2	+0.7			
54	731.0		66.5	66.3	62.8	+0.2			
53	737.5		65.5	65.4	61.6	+0.1			
52	742.8	Apr. 5-7	64.4	64.3	60.0	+0.1			
51a	747.5	Apr. 5-9	63.6	63.6		0.0			
50	751.5	Apr. 8-9	62.8	63.2	57.9	−0.4			
49	756.0		62.0	62.3	56.4	−0.3			
48	761.0	Apr. 9	61.4	61.5	55.5	−0.1			
Red River Landing	765.3	Apr. 8, 9	60.7	60.9	55.0	−0.2	49.98	1897	50.20

Table No. 5.—*High water, Mississippi River, Cairo to Head of Passes, 1903*—Continued.

Number of gauge.	Distance from Cairo.	Date of highest reading in 1903.	Elevation above Memphis datum.			Difference between 1897 and 1903.	Regular gauge readings.		
			1903.	1897.	1898.		1903.	Previous highest.	
	Miles.		*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Yrs.*	*Feet.*
47	769.0		60.0	60.0	54.0	0.0			
46	772.5	Apr. 7-9	59.6	59.7	53.8	−0.1			
45	779.8	Apr. 10-13	57.9	58.2	52.0	−0.3			
44	784.8		57.3	57.5	51.4	−0.2			
43	790.5		56.0	56.3	49.6	−0.3			
42	794.5	Apr. 11	55.1	55.5	48.7	−0.4			
Bayou Sara	799.8	Apr. 8-10	54.2	54.6	48.3	−0.4	43.34	1897	43.7
41	803.5	do	52.8	53.3	47.2	−0.5			
40	808.0	Apr. 10	52.8	53.2	46.2	−0.4			
39	812.5	Apr. 5, 6	51.4	52.2	45.8	−0.8			
38	817.0	Apr. 8-10	50.4	50.6	44.2	−0.2			
37	822.5	Apr. 8	50.0	50.1	43.9	−0.1			
36	828.5		47.8	48.4	42.2	−0.6			
Baton Rouge	833.3	Apr. 10	47.0	47.6	41.5	−0.6	40.05	1897	40.65
35	839.5		46.4	46.9	40.6	−0.5			
34	844.2		45.5	45.9	39.8	0.4			
33	850.0	Apr. 5	44.4	44.5	38.7	−0.1			
Plaquemine	854.1	Apr. 5, 7, 8	44.1	44.2	38.5	−0.1	36.16	1897	36.25
32	859.8	Apr. 2-4	42.8	43.0	37.5	−0.2			
31	864.2	Apr. 4	42.0	42.1	36.8	−0.1			
30	869.8	Apr. 5-8	41.0	41.3	35.9	−0.3			
29	874.5	Apr. 9, 10	40.6	40.7	35.6	−0.1			
28	880.0	Apr. 7, 8	39.7	40.1	35.0	−0.4			
Donaldsonville	885.4	Apr. 7	38.8	39.1	34.3	−0.3	32.23	1897	32.75
27	889.8	Apr. 5-9	38.5	38.9	33.9	−0.4			
26	895.8		37.4	37.6	32.9	−0.2			
25	900.3	Apr. 5	36.2	36.7	32.2	−0.5			
College Point	904.5	Apr. 5, 6	35.9	36.1	31.6	−0.2	27.80	1897	27.95
24	910.5		34.5	34.7	30.5	−0.2			
23	914.8	Apr. 7	33.8	33.9	29.9	−0.1			
22	919.8	do	33.1	33.1	29.2	0.0			
21	925.5	Apr. 9	32.2	32.0	28.6	+0.2			
20	930.5	Apr. 7	31.1	31.1	27.3	0.0			
19	934.3	Apr. 7-9	30.7	30.2	26.9	+0.5			
18	937.8	Mar. 29, 30, Apr. 7, 8.	29.9	29.4	26.2	+0.5			
17	943.5	Mar. 30, Apr. 8	29.2	28.9	25.4	+0.3			
16	948.0	Mar. 24	28.9	28.1	25.1	+0.8			
15	953.0	Mar. 29, Apr. 6-8.	27.5	27.2	24.2	+0.3			
Carrollton	957.0	Mar. 29, Apr. 5	27.2	27.0	23.7	+0.2	19.42	1897	19.17
14	968.0	Mar. 26-30, Apr. 5-7.	24.6	24.0	22.0	+0.6			
13	973.5	Mar. 28	24.1	23.8	20.9	+0.3			
12	979.2		22.8	22.1	19.8	+0.7			
11	983.5	Apr. 5, 6	21.9	21.0	19.1	+0.9			
10	989.3	Mar. 28	21.0	20.4	18.6	+0.6			
9	993.0		20.2	19.4	17.7	+0.8			
8	999.0	Mar. 18, 19	19.5	19.1	17.4	+0.4			
7	1,003.8	Mar. 23, 24	19.0	18.1	16.5	+0.9			
6	1,008.2	Mar. 23-31	18.0	17.4	16.4	+0.6			
5	1,013.0	Mar. 29	17.8	16.9	15.7	+0.9			
4	1,019.0	Mar. 22-27	16.9	15.9	14.6	+1.0			
3	1,023.8	Mar. 24	16.7	15.5	14.4	+1.2			
2	1,029.0	Mar. 22-25	15.8	14.8	13.9	+1.0			
1	1,034.0	Mar. 25	14.7	14.0	13.3	+0.7			
Fort Jackson	1,039.0	Mar. 27	14.1	13.3	12.8	+0.8	8.00	1897	7.2

TABLE NO. 6.—*Highest gauge readings in 1903 (to June 30) at stations on the Mississippi River above Cairo and on tributaries of the Mississippi River.*

Station.	River.	Date.	Gauge reading, 1903.	Previous highest.		Difference.
				Gauge reading.	Year.	
			Feet.	*Feet.*		
Davenport, Iowa	Mississippi	June 4-6	13.2	19.4	1892	− 6.2
Grafton, Ill	do	June 11	28.4	25.73	1892	+ 2.67
St. Louis, Mo	do	June 10	38.00	[a] 35.95	1892	+ 2.05
Chester, Ill	do	June 13, 14	33.3	31.2	1892	+ 2.1
Cape Girardeau, Mo	do	June 14	36.5	....	1892	[b] + 0.4
Little Rock, Ark	Arkansas	June 2	26.2	31.20	1892	− 5.00
Barbre Landing, La	Atchafalaya	Apr. 7-11	50.60	50.95	1897	− .35
West Melville, La	do	Apr. 4	38.7	37.00	1882	+ 1.7
Nashville, Tenn	Cumberland	Mar. 9	40.60	55.30	1882	−14.70
Peoria, Ill	Illinois	Mar. 12	19.3	21.9	1892	− 2.6
Hermann, Mo	Missouri	June 6	29.1	[c] 24.8	1892	+ 4.3
Cincinnati, Ohio	Ohio	Mar. 5	53.1	71.06	1884	−17.96
Louisville, Ky. (upper)	do	Mar. 9	28.5	46.60	1884	−18.10
Louisville, Ky. (lower)	do	do	54.3	72.00	1884	−17.70
Paducah, Ky	do	Mar. 16	47.6	54.25	1884	− 6.65
Camden, Ark	Ouachita	Feb. 20, Mar. 14	39.60	46.0	1882	− 6.40
Monroe, La	do	Mar. 26-28	44.5	48.60	1882	− 4.10
Fulton, Ark	Red	Mar. 14	31.15	35.75	1876	− 4.60
Shreveport, La	do	Mar. 21-23	33.10	35.70	1892	− 2.60
Alexandria, La	do	Mar. 27, 28	36.05	38.25	1892	− 2.20
Bridge St. Louis, Iron Mountain and Southern Rwy.	St. Francis	Apr. 2-3	32.9	41.6	1897	− 8.7
Chattanooga, Tenn	Tennessee	Apr. 11	31.8	54.00	1875	−22.20
Florence, Ala	do	Mar. 6	18.80	32.20	1897	−13.40
Mount Carmel, Ill	Wabash	Mar. 12	22.3	28.3	1875	− 6.0
Jacksonport, Ark	White	do	29.80	33.35	1890	− 3.55
Clarendon, Ark	do	Mar. 20	32.65	36.63	1890	− 3.98
Yazoo City, Miss	Yazoo	Apr. 6-8	28.7	36.50	1882	− 7.80

[a] High water of June 28, 1844, would read 41.4 feet.
[b] Cape Girardeau established in 1896; difference given is taken from Grays Point record.
[c] High water of June, 1844, would read 35.6 feet.

TABLE NO. 7.—*Results of discharge observations, Mississippi River.*

ST. LOUIS, MO. (FOOT OF ARSENAL STREET).

Date.	Gauges.			Cross section of discharge.						Scour or fill.	Mean velocity per second.	Discharge per second.	Discharge over bank per second.	Total discharge of river per second.	Method.	Number of velocity stations.	Number of soundings.	Direction and force of wind.
	Standard gauge.	Local.	Change in twenty-four hours.	Area.		Depth.			Width.									
				Water.	Below datum.	Mean.	Mean datum.	Maximum.										
1902.	*Feet.*	*Feet.*	*Feet.*	*Sq. feet*	*Sq. feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Sq.feet.*	*Feet.*	*Cub. feet.*	*Cub. feet.*	*Cub. feet.*				
July 18-19...	a26.38	25.39	+0.2	78,696	....	29.4	....	41	2,677	....	5.44	427,694	....	....	M.	....	....	VII, light to strong.

a U. S. engineer's gauge at foot of market street. Elevation of zero above Cairo datum 400.23 feet. For additional notes, see page 121.

Haskell meter, wheel No. ¼ used. Constants: $a=1.85124$; $b=+0.11591$.

Discharge section at foot of Arsenal street, St. Louis, Mo.

Area of cross section derived from two sets of soundings which were made from steamboat flanking across stream. Three-eighths inch lead line with about 16 pound lead used.

GRAFTON, ILL. (234 MILES ABOVE CAIRO).

Date.	Gauges.			Cross section of discharge.						Scour or fill.	Mean velocity per second.	Discharge per second.	Discharge over bank per second.	Total discharge of river per second.	Method.	Number of velocity stations.	Number of soundings.	Direction and force of wind.
	Standard gauge.	Local.	Change in twenty-four hours.	Area.		Depth.			Width.									
				Water.	Below datum.	Mean.	Mean datum.	Maximum.										
1903.	*Feet.*	*Feet.*	*Feet.*	*Sq. feet.*	*Sq. feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Sq.feet.*	*Feet.*	*Cub. feet.*	*Cub. feet.*	*Cub. feet.*				
June 10......	a28.2	1.33	+0.4	112,146	112,656	33	33.1	46.1	3,400	....	2.80	314,321	b47,532	361,853	M.	18	32	III, strong.
June 11 a. m.	28.4	1.48	+ .2	113,854	113,854	33.5	33.5	46.1	3,400	+1,198	2.79	317,223	b48,314	365,537	M.	22	32	III, strong.
June 11 p. m.	....	1.46	....	111,938	112,006	32.9	32.9	45.2	3,400	−1,848	2.77	310,604	b48,210	358,814	M.	21	32	III, strong.

a Grafton weather bureau gauge. Zero is 424.09 feet above the Cairo datum plane. The datum line was at 1.48 feet on the local gauge.

b The overbank discharge was measured on June 12. All overbank discharges were deduced from these observations. For additional notes, see page 121.

Haskell meter, wheel No. 11 used. Constants: $a=2.12722$; $b=+0.07838$.

The discharge section was opposite central part of town of Lower Grafton. Overbank discharge measured on both banks.

TABLE No. 7.—*Results of discharge observations, Mississippi River*—Continued.

THEBES, ILL. (44.5 MILES ABOVE CAIRO).

Date.	Gauges.			Cross section of discharge.						Scour or fill.	Mean velocity per second.	Discharge per second.	Discharge over bank per second.	Total discharge of river per second.	Method.	Number of velocity stations.	Number of soundings.	Direction and force of wind.
	Standard gauge.	Local.	Change in twenty-four hours.	Area.		Depth.			Width.									
				Water.	Below datum.	Mean.	Mean datum.	Maximum.										
1903.	*Feet.*	*Feet.*	*Feet.*	*Sq. feet.*	*Sq. feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Sq. feet.*	*Feet.*	*Cub. feet.*	*Cub. feet.*	*Cub. feet.*				
June 6	[a] 31.83	30.35	+1	98,032	108,971	37.9	42.1	49.8	2,586	....	7.05	691,467	....	....	[b] M.	18	67	XI, calm to brisk.
June 8	33.73	32.10	+ .9	102,587	109,000	39.7	42.2	52.4	2,586	+ 29	7.31	749,646	[c] 1,248	750,894	M.	16	71	Calm.
June 9	34.43	32.85	+ .7	104,770	109,244	40.5	42.2	52.9	2,586	+ 244	7.94	831,420	[c] 3,642	835,062	M.	17	86	XII, brisk.
June 10 a. m.	34.93	33.26	+ .5	[d] 105,244	....	40.7	....	....	....	....	8.17	859,834	[c] 6,897	866,731	F.	16	....	XII, light.
June 10 p. m.	35.23	33.38	....	[d] 105,244	....	40.7	....	....	....	....	8.40	884,296	[c] 6,897	891,193	M.	16	....	XII, brisk.
June 11	35.43	33.74	+ .5	105,716	107,888	40.9	41.7	52.4	2,586	−1,356	8.49	897,915	[c] 9,482	907,397	M.	17	82	XII, strong.
June 12 a. m.	35.83	34.07	+ .4	[d] 105,727	....	40.9	....	....	....	....	8.18	865,214	[c] 10,953	876,167	F.	17	....	XII, brisk.
June 12 p. m.	35.98	34.13	....	[d] 105,727	....	40.9	....	....	....	....	8.56	905,161	[c] 10,953	916,114	M.	16	....	XII, light.
June 13	36.13	34.34	+ .3	105,739	106,360	40.9	41.1	52.8	2,586	−1,528	8.60	909,389	[c] 12,022	921,411	M.	16	70	Do.
June 14	36.33	34.60	+ .2	[e] 105,563	....	40.8	....	....	....	....	9.47	999,739	[c] 14,176	1,013,915	M.	16	....	Do.
June 15	36.43	34.58	+ .1	105,563	105,563	40.8	40.8	52.7	2,586	− 797	9.42	994,754	14,176	1,008,930	M.	17	77	Do.

[a] The zero of the M. R. C. gauge at Cape Girardeau, whose readings are tabulated, is 324.97 feet above the Cairo datum plane.

[b] M indicates meter, F indicates double floats.

[c] All overbank discharges were deduced from observations made on June 15.

[d] Interpolated.

[e] Used area of June 15.

For additional notes, see page 121.

Haskell Meter, wheel No. 4 used. Constants: $a = 2.08430$; $b = +0.08629$.

The discharge section is as laid out in 1898, and is about center of street immediately below Chicago and Eastern Illinois Railroad depot. It is about 9 miles below Cape Girardeau, Mo., overbank discharge measured along railroad, parallel to river, about 2¼ miles below Cape Girardeau.

The local gauge used is Thebes gauge, set by bridge engineers. Elevation of zero is 320.47 feet above the Cairo datum plane. The datum line was at 34.58 feet on this gauge.

COLUMBUS, KY. (22 MILES BELOW CAIRO.)

Date.	Gauges.			Cross section of discharge.						Scour or fill.	Mean velocity per second.	Discharge per second.	Discharge over bank per second.	Total discharge of river per second.	Method.	Number of velocity stations.	Number of soundings.	Direction and force of wind.
	Standard gauge.	Local.	Change in twenty-four hours.	Area.		Depth.			Width.									
				Water.	Below datum.	Mean.	Mean datum.	Maximum.										
1903.	Feet.	Feet.	Feet.	Sq. feet.	Sq. feet.	Feet.	Feet.	Feet.	Feet.	Sq. feet.	Feet.	Cub. feet.	Cub. feet.	Cub. feet.				
Mar. 16-17...	a 44.46	....	+0.05	193,191	....	62.6	....	97	3,085	....	7.68	1,483,431	....	....	M.	17	105	Calm.

a M. R. C. gauge at Columbus. Zero is 286.76 feet above the Cairo datum plane.

Haskel meter, wheel No. 11 used. Constants. $a = 2.12722$; $b = +0.07638$.

The discharge section was at same place as in 1900 and 1901, opposite town of Columbus.

Discharge observed with Haskell meter run at one-tenth, two-tenths, three tenths, four-tenths, and six-tenths depth; all velocities were reduced to six-tenths depth, by applying the following coefficients, viz, for one-tenth 1.0159, for two-tenths 0.9836, for three-tenths 0.9754, for four-tenths 0.9687.

Water was about 3 feet deep on the right bank for quite a distance into the woods, but no current was perceptible.

For additional notes, see page 121.

HELENA, ARK. (307 MILES BELOW CAIRO).

Date.	Gauges.			Cross section of discharge.						Scour or fill.	Mean velocity per second.	Discharge per second.	Discharge over bank per second.	Total discharge of river per second.	Method.	Number of velocity stations.	Number of soundings.	Direction and force of wind.
	Standard gauge.	Local.	Change in twenty-four hours.	Area.		Depth.			Width.									
				Water.	Below datum.	Mean.	Mean datum.	Maximum.										
1903.	Feet.	Feet.	Feet.	Sq. feet.	Sq. feet.	Feet.	Feet.	Feet.	Feet.	Sq. feet.	Feet.	Cub. feet.	Cub. feet.	Cub. feet.				
Mar. 20	a 49.85	....	+0.47	208,146	217,208	40.2	41.9	98	5,178	....	6.24	1,299,012	b 58,931	1,357,943	c M.	32	71	X, medium.
Mar. 21	49.70	....	+ .35	215,430	221,747	41.6	42.8	101	5,178	+ 4,539	6.22	1,339,087	62,322	1,401,409	M.	31	95	XI, light.
Mar. 22	50.03	....	+ .33	211,426	215,983	40.8	41.7	100	5,178	− 5,764	6.56	1,387,067	b 64,472	1,451,539	M.	28	86	III, light.
Mar. 23	50.40	....	+ .37	210,483	212,968	40.6	41.1	101.3	5,178	− 3,015	6.71	1,412,965	b 67,015	1,479,980	M.	26	92	V, light.
Mar. 24	50.68	....	+ .28	211,987	213,799	40.9	41.3	101.3	5,178	+ 831	6.46	1,369,951	b 67,836	1,437,787	M.	29	98	XI, light.
Mar. 25 a. m.	50.88	....	+ .20	228,677	229,143	44.2	44.2	105.3	5,178	+15,344	6.51	1,488,751	b 69,494	1,558,245	M.	27	127	XII, light.
Mar. 25 p. m.	50.90	....									7.07	1,616,888	b 69,494	1,686,382	F.	17	....	Do.
Mar. 26	51.00	....	+ .10	218,081	218,081	42.1	42.1	107.3	5,178	−11,062	6.71	1,463,726	b 70,064	1,533,790	M.	32	121	II, light.

a M. R. C. gauge at Helena. Zero is 161.98 feet above the Cairo datum plane. The datum line was at 51 feet on the gauge.

b Overbank discharge was observed on March 21. All overbank discharges derived from this measurement.

c M indicates meter. F indicates double floats.

Haskell meter, wheel No. 11 used. Constants: $a=2.12722$; $b=+0.07638$.

The discharge section was at same place as in 1898 and 1901, about one-half mile below Helena, Ark. Overbank discharge measured on left bank.

For additional notes, see page 121.

TABLE NO. 7.—*Results of discharge observations, Mississippi River*—Continued.

ARKANSAS CITY, ARK. (439 MILES BELOW CAIRO).

Date.	Gauges.			Cross section of discharge.						Scour or fill.	Mean velocity per second.	Discharge per second.	Discharge over bank per second.	Total discharge of river per second.	Method.	Number of velocity stations.	Number of soundings.	Direction and force of wind.
	Arkansas City, Mississippi River Commission gauge.	Local.	Change in twenty-four hours.	Area.		Depth.			Width.									
				Water.	Below datum.	Mean.	Mean datum.	Maximum.										
1903.	*Feet.*	*Feet.*	*Feet.*	*Sq. feet*	*Sq. feet*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Sq. feet.*	*Feet.*	*Cub. feet.*	*Cub. feet.*	*Cub. feet.*				
Mar. 8	[a] 48.0	....	+0.2	254.397	257,959	71.4	72.4	96.2	8,562	....	5.08	1,292,098	....	....	M.	5	24	X, light.
Mar. 11	48.8	....	+0.2	238,181	239,072	66.9	67.1	96.7	8,562	−18,887	5.40	1,285,667	....	....	M.	10	32	Do.
Mar. 12	49.0	....	+0 2	238,841	238,841	67.0	67.0	97.8	8,562	− 231	5.02	1,198,416	....	....	M.	18	73	Do.

[a] Zero of Mississippi River Commission gauge at Arkansas City, whose readings are tabulated, is 116.44 feet above the Cairo datum plane. Datum line was at 49 feet on the gauge.

Haskell meter, wheel No. 2 used, constants: $a=1.89607$, $b=+0.05833$.

The discharge section is the same as used in 1898. It is about one-half mile below Arkansas City.

For additional notes see page 121.

CHICOT CITY, ARK. (432 MILES BELOW CAIRO).

Date.	Gauges.			Cross section of discharge.						Scour or fill.	Mean velocity per second.	Discharge per second.	Discharge over bank per second.	Total discharge of river per second.	Method.	Number of velocity stations.	Number of soundings.	Direction and force of wind.
	Arkansas City, Mississippi River Commission gauge.	Local.	Change in twenty-four hours.	Area.		Depth.			Width.									
				Water.	Below datum.	Mean.	Mean datum.	Maximum.										
1908.	*Feet.*	*Feet.*	*Feet.*	*Sq. feet.*	*Sq. feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Sq. feet.*	*Feet.*	*Cub. feet.*	*Cub. feet.*	*Cub. feet.*				
Mar. 14	[a] 49.6	154.40	+0.3	230,659	244,556	53.9	57.2	78.7	4,276								45	
Mar. 16	50.4	155.16	+0.4	[b] 230,425		53.9					7.54	1,736,690	6,514	1,743,204	[c] M.	13		Calm.
Mar. 17	50.8	155.65	+0.4	230,192	238,744	53.8	55.8	71.4	4,276	−5,812	6.81	1,568,021	[b] 7,859	1,575,880	M.	20	66	Calm to VIII, light.
Mar. 18	51.2	156.07	+0.4	228,831	235,587	53.5	55.1	69.4	4,276	−3,157	6.40	1,465,740	[b] 9,204	1,474,944	M.	18	57	VI to VIII, brisk.
Mar. 19	51.6	156.44	+0.4	235,409	240,583	55.0	56.3	71.5	4,276	+4,996	7.00	1,646,909	[b] 10,549	1,657,458	F.	15	73	VII, strong.
Mar. 20	51.9	156.78	+0.3	239,560	243,280	56.0	56.9	72.7	4,276	+2,697	6.84	1,637,492	11,895	1,649,387	M.	19	65	I, brisk.
Mar. 21, a. m.	52.2	157.02	+0.3	236,427	239,121	55.3	55.9	71.9	4,276	−4,159	6.65	1,573,148	[b] 11,279	1,584,427	M.	16	72	II, light.
Mar. 21, p. m	52.3	157.02									6.80	1,606,497	[b] 11,279	1,617,776	F.	11		II, breeze.
Mar. 22	52.4	157.18	+0.2	236,270	238,280	55.2	55.7	73.2	4,276	− 841	6.76	1,596,215	[b] 10,663	1,606,878	M.	14	64	Do.
Mar. 23	52.6	157.35	+0.2	233,951	235,234	54.7	55.0	73.3	4,276	−3,046	6.79	1,588,436	10,048	1,598,484	M.	15	71	II, strong.
Mar. 24	52.7	157.47	+0.1	237,649	238,419	55.6	55.8	73.6	4,276	+3,185	6.96	1,654,446	[b] 10,161	1,664,607	M.	17	71	II, light.
Mar. 25, a. m.	52.7	157.60	0.0	230,763	230,977	54.0	54.0	66.5	4,276	−7,442	6.95	1,603,800	[b] 10,286	1,614,086	M.	16	99	Do.
Mar. 25, p. m	52.8	157.60									7.14	1,647,097	[b] 10,286	1,657,383	F.	15		Do.
Mar. 26	52.9	157.65	+0.2	234,896	234,896	54.9	54.9	67.6	4,276	+3,919	7.24	1,699,921	[b] 10,833	1,710,254	M.	17	72	

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[a] Zero of Mississippi River Commission gauge at Arkansas City, whose readings are tabulated, is 116.44 feet above the Cairo datum plane.

[b] Interpolated.

[c] M indicates meter; F indicates double floats.

Haskell meter, wheel No. ¼ used, constants: $a = 2.08430$, $b = 0.08629$.

The discharge section is 232 meters above prominent right angle in levee below Chicot, Ark., and 20 meters below church on left bank. Over-bank discharge measured on both banks.

Local gauge used is high-water gauge 105 above Eutaw Landing, Miss. Zero of this gauge is 13.13 feet above the Cairo datum plane. The datum line was at 157.65 feet on local gauge.

For additional notes see page 121.

TABLE NO. 7.—*Results of discharge observations, Mississippi River*—Continued.

VICKSBURG, MISS. (600 MILES BELOW CAIRO).

Date.	Gauges.			Cross section of discharge.						Scour or fill.	Mean velocity per second.	Discharge per second.	Discharge over bank per second.	Total discharge of river per second.	Method.	Number of velocity stations.	Number of soundings.	Direction and force of wind.
	Standard gauge.	Local.	Change in twenty-four hours.	Area.		Depth.			Width.									
				Water.	Below datum.	Mean.	Mean datum.	Maximum.										
1903.	*Feet.*	*Feet.*	*Feet.*	*Sq. feet.*	*Sq. feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Sq. feet.*	*Feet.*	*Cub. feet.*	*Cub. feet.*	*Cub. feet.*				
Mar. 31, a. m.	[a] 51.38	51.33	−0.05	205,984	205,984	86.2	86.2	141.7	2,389	....	7.44	1,531,581	[b] 74,626	1,606,207	[c] M.	13	46	VII, light.
Mar. 31, p. m.	51.35	51.33		....	....	....	....	....	....	....	7.47	1,538,988	[b] 74,626	1,613,614	F.	13	....	Do.
Apr. 1	51.30	51.28	−0.08	199,794	199,913	83.6	83.7	141.6	2,389	−6,071	7.55	1,508,693	[b] 74,392	1,583,085	M.	14	61	VII, brisk.
Apr. 2	51.20	51.28	−0.10	199,824	199,943	83.6	83.7	141.6	2,389	+ 30	7.38	1,474,853	74,392	1,549,245	M.	11	40	Do.
Apr. 4	50.95	50.90	−0.20	203,463	204,490	85.2	85.6	141.5	2,389	+4,547	7.30	1,486,221	[b] 72,607	1,558,828	M.	14	53	XII to X, brisk.

[a] The zero of the Vicksburg U. S. engineer gauge is 66.04 feet above the Cairo datum plane.

[b] Derived from observations made on April 2.

[c] M indicates meter; F indicates double floats.

Haskell meter wheel No. 1 used, constants: $a=2.08430$, $b=+0.08629$.

The discharge section is 365 meters below Refuge oil mill, below Kleinston, below Vicksburg, Miss. Over-bank discharge measured on right bank.

The local gauge was set to read same as the Vicksburg United States engineer gauge, whose readings are tabulated. The datum line was at 51.33 feet on local gauge.

For additional notes see page 121.

RED RIVER LANDING, LA. (766 MILES BELOW CAIRO).

Date.	Gauges.			Cross section of discharge.						Scour or fill.	Mean velocity per second.	Discharge per second.	Discharge over bank per second.	Total discharge of river per second.	Method.	Number of velocity stations.	Number of soundings.	Direction and force of wind.
	Standard gauge.	Local.	Change in twenty-four hours.	Area.		Depth.			Width.									
				Water.	Below datum.	Mean.	Mean datum.	Maximum.										
1903.	*Feet.*	*Feet.*	*Feet.*	*Sq. feet.*	*Sq. feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Sq. feet.*	*Feet.*	*Cub. feet.*	*Cub. feet.*	*Cub. feet.*				
Apr 8	[a]49.98	....	+0.06	230,263	230,263	55.0	55.0	82.1	4,187	....	5.20	1,196,871	9,283	1,206,154	M.	16	78	III, nearly calm.
Apr. 10	49.98	....	0.00	220,219	220,219	52.6	52.6	88.4	4,187	--10,044	5.05	1,112,313	[b]9,283	1,121,596	M.	15	84	

[a] U. S. engineer gauge at Red River Landing whose readings are tabulated. Zero is 3.57 feet above mean Gulf level.

[b] Deduced from observations of April 8.

Haskell meter, wheel No. ¼ used on April 8 and part of April 10, constants: $a=2.08430$, $b=+0.08629$. Price meter No. 40 used for part of April 10, constants: $a=3.96470$, $b=+0.18146$.

The discharge section is the same as in 1898. Just below Red River Landing. Over-bank discharge measured on right bank.

For addditional notes see page 121.

ATCHAFALAYA RIVER, SIMMESPORT, LA. (4 MILES BELOW HEAD).

Date.	Gauges.			Cross section of discharge.						Scour or fill.	Mean velocity per second.	Discharge per second.	Discharge over bank per second.	Total discharge of river per second.	Method.	Number of velocity stations.	Number of soundings.	Direction and force of wind.
	Standard gauge.	Local.	Change in twenty-four hours.	Area.		Depth.			Width.									
				Water.	Below datum.	Mean.	Mean datum.	Maximum.										
1903.	*Feet.*	*Feet.*	*Feet.*	*Sq. feet.*	*Sq. feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Sq. feet.*	*Feet.*	*Cub. feet.*	*Cub. feet.*	*Cub. feet.*				
Apr. 9	[a]50.60	....	0.00	71,141	....	60.2	....	99.1	1,182	....	5.41	384,685	3,370	388,055	[b]M.	9	51	Calm.
Apr. 9	....	....	....	....	....	....	....	....	....	....	5.27	374,877	3,370	378,247	F.	11	....	Do.

[a] Barbre Landing, Mississippi River Commission gauge at the head of the Atchafalaya River, 4 miles above Simmesport. Zero of gauge is 3.91 feet above mean Gulf level.

[b] M. indicates meter; F. indicates double floats.

Haskell meter, wheel No. ¼ used, constants: $a=2.08430$, $b=+0.08629$.

The discharge section is 30 meters below store at Simmesport Landing. Over-bank discharge measured on left bank.

For additional notes see page 121.

TABLE NO. 7.—*Results of discharge observations, Mississippi River*—Continued.

CARROLLTON, LA. (957 MILES BELOW CAIRO).

Date.	Gauges.			Cross section of discharge.						Scour or fill.	Mean velocity per second.	Discharge per second.	Discharge over bank per second.	Total discharge of river per second.	Method.	Number of velocity stations.	Number of soundings.	Direction and force of wind.
	Standard gauge.	Local.	Change in twenty-four hours.	Area.		Depth.			Width.									
				Water.	Below datum.	Mean.	Mean datum.	Maximum.										
1903.	*Feet.*	*Feet.*	*Feet.*	*Sq. feet.*	*Sq. feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Sq. feet.*	*Feet.*	*Cub. feet.*	*Cub. feet.*	*Cub. feet.*				
Apr. 12	[a] 19.10	....	−0.05	197,911	197,911	88.7	88.7	124.9	2,230	....	6.58	1,302,503	[b] 2,989	1,305,492	[c] M.	10	51	VII, strong.
Apr. 13	19.05	....	−0.05	198,546	198,658	89.0	89.1	124.2	2,230	− 747	6.60	1,311,302	2,967	1,314,269	M.	13	56	IX to X, strong.
Apr. 14	19.00	....	−0.05	201,547	201,748	90.4	90.5	121.4	2,230	+3,090	6.62	1,334,654	[b] 2,948	1,337,602	M.	12	55	X, strong.
Apr. 15, a. m.	18.90	....	−0.10	....	....	....	....	....	....	....	6.53	1,294,696	[b] 2,915	1,297,611	F.	12	....	XI, brisk.
Apr. 15, p. m.	18.90	....	....	198,385	198,764	89.0	89.1	119.3	2,230	−2,984	6.51	1,291,241	[b] 2,915	1,294,156	M.	12	61	X, brisk.
Apr. 16, a. m.	18.80	....	−0.10	....	....	....	....	....	....	....	6.48	1,286,852	[b] 2,840	1,289,692	F.	12	....	IX, nearly calm.
Apr. 16, p. m.	18.80	....	....	198,655	199,413	89.1	89.4	121.1	2,230	+ 649	6.53	1,296,221	[b] 2,840	1,299,061	M.	13	52	X, light, to XI, strong.

[a] U. S engineer gauge at Carrollton. Zero is 0.131 foot below mean Gulf level. Datum line was at 19.10 on the gauge.

[b] Derived from observations made on April 13.

[c] M indicates meter; F indicates double floats.

Haskell meter, wheel No. ½ used, constants: $a=2.08430$, $b=+0.08629$.

The discharge section is the same as used in 1898, 1¼ blocks above Carrollton avenue. Over-bank discharge measured on both banks.

For additional notes see page 121.

BAYOU LAFOURCHE, DONALDSONVILLE, LA. (885 MILES BELOW CAIRO).

Date.	Gauges.			Cross section of discharge.						Scour or fill.	Mean velocity per second.	Discharge per second.	Discharge over bank per second.	Total discharge of river per second.	Method.	Number of velocity stations.	Number of soundings.	Direction and force of wind.
	Standard gauge.	Local.	Change in twenty-four hours.	Area.		Depth.			Width.									
				Water.	Below datum.	Mean.	Mean datum.	Maximum.										
1903.	*Feet.*	*Feet.*	*Feet.*	*Sq. feet.*	*Sq. feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Sq. feet.*	*Feet.*	*Cub. feet.*	*Cub. feet.*	*Cub. feet.*				
Apr. 11	[a] 31.95	....	−0.10	5,181	....	23.6	....	34.5	220	....	4.45	23,055	....	....	M.	5	22	Calm.

[a] Donaldsonville U. S. engineer gauge. Zero is 1.01 feet below mean Gulf level.

Price meter No. 40 used, constants: $a=3.96470$, $b=+0.18146$.

The discharge section was at the Texas and Pacific Railroad bridge.

For additional notes see page 121.

ARKANSAS RIVER, LITTLE ROCK, ARK. (176 MILES ABOVE MOUTH).

Date.	Gauges.			Cross section of discharge.						Scour or fill.	Mean velocity per second.	Discharge per second.	Discharge over bank per second.	Total discharge of river per second.	Method.	Number of velocity stations.	Number of soundings.	Direction and force of wind.
				Area.		Depth.												
	Standard gauge.	Local.	Change in twenty-four hours.	Water.	Below datum.	Mean.	Mean datum.	Maximum.	Width.									
1903.	*Feet.*	*Feet.*	*Feet.*	*Sq. feet.*	*Sq. feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Sq. feet.*	*Feet.*	*Cub. feet.*	*Cub. feet.*	*Cub. feet.*				
June 1	[a]25.50	....	+0.90	32,453	32,788	31	31.3	41.5	1,046	....	....	....	....	....	....	....	68	
June 2	26	....	+ .50	33,620	33,693	32.1	32.2	44	1,046	+905	6.97	234,464	....	....	M.	20	61	X, light.
June 3	26.10	....	+ .10	33,569	33,569	32.1	32.1	40	1,046	−124	8.40	282,128	....	....	M.	18	73	Calm.

[a] Little Rock. U. S. engineers' gauge. Zero is 241.582 feet above the Cairo datum plane.

Haskell meter, wheel No. 1, used on June 2. Constants: $a = 1.21572$; $b = +0.13312$. Haskell meter wheel No. 11 used on June 3. Constants: $a = 2.12722$; $b = +0.07688$.

The discharge section was about 360 meters below the St. Louis Iron Mountain and Southern R. R. bridge at Little Rock, Ark., and about 10 meters below the end of State street.

The datum line was at 26.12 feet on the gauge.

For additional notes see page 121.

YAZOO RIVER, YAZOO AND MISSISSIPPI VALLEY R. R. BRIDGE (16 MILES ABOVE MOUTH).

Date.	Gauges.			Cross section of discharge.						Scour or fill.	Mean velocity per second.	Discharge per second.	Discharge over bank per second.	Total discharge of river per second.	Method.	Number of velocity stations.	Number of soundings.	Direction and force of wind.
				Area.		Depth.												
	Standard gauge.	Local.	Change in twenty-four hours	Water.	Below datum.	Mean.	Mean datum.	Maximum.	Width.									
1903.	*Feet.*	*Feet.*	*Feet*	*Sq. feet.*	*Sq. feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Sq. feet.*	*Feet.*	*Cub. feet.*	*Cub. feet.*	*Cub. feet.*				
Mar. 29	[a]28.40	[b]98.80	+0.10	40,489	40,489	37.5	37.5	78.5	1,081	....	1.37	55,463	....	....	M.	19	71	XI, light.
Mar. 30	28.50	98.80	+ .10	39,933	39,933	36.9	36.9	78	1,081	− 556	1.51	60,454	....	....	M.	20	71	Do.
Do	....	98.80	....	....	....	....	....	....	....	....	1.54	61,620	....	....	M.	20	....	

[a] Yazoo City weather bureau guage. Zero is 93.34 feet above the Cairo datum plane.

[b] Zero of local gauge is 20.85 feet above the Cairo datum plane. H. W. of 1897 would read 100.68 feet on this gauge,

Haskell meter, wheel No. 1, used. Constants: $a = 1.21572$; $b = +0.13312$.

The discharge section was at the Yazoo and Mississippi Valley R. R. bridge over the Yazoo River.

For additional notes see page 121.

TABLE No. 7.—*Results of discharge observations*—Continued.

RED RIVER, ALEXANDRIA, LA. (110 MILES ABOVE MOUTH).

Date.	Gauges.			Cross section of discharge.						Scour or fill.	Mean velocity per second.	Discharge per second.	Discharge over bank per second.	Total discharge of river per second.	Method.	Number of velocity stations.	Number of soundings.	Direction and force of wind.
	Standard gauge.	Local.	Change in twenty-four hours.	Area.		Depth.			Width.									
				Water.	Below datum.	Mean.	Mean datum.	Maximum.										
1908.	*Feet.*	*Feet.*	*Feet.*	*Sq. feet.*	*Sq. feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Sq. feet.*	*Feet.*	*Cub. feet.*	*Cub. feet.*	*Cub. feet.*				
Apr. 2	[a]35.70	....	−0.05	28,208	28,208	34.5	34.5	50.4	818	....	4.79	135,122	....	....	M.	13	66	VIII, strong.
Apr. 4, a. m.	35.40	....	− .20	28,084	28,223	34.3	34.5	50.9	818	+ 20	5	140,431	....	....	M.	15	78	III, light.
Apr. 4, p. m.	35.30	....	....	27,709	27.889	33.9	34.1	51.4	818	−334	5.05	140,041	....	....	M.	15	50	IV, light.

[a] Alexandria. U. S. engineers' gauge. Zero is 44.18 feet above mean Gulf level. Datum line was at 35.88 feet on the gauge.

Haskel meter, wheel No. 11, used. Constants: $a = 2.12722$; $b = +0.07638$.
The discharge section was at same place as in 1895, about 260 meters below Highway bridge.
For additional notes see page 121.

BLACK RIVER, JONESVILLE, LA. (54 MILES ABOVE MOUTH).

Date.	Gauges.			Cross section of discharge.						Scour or fill.	Mean velocity per second.	Discharge per second.	Discharge over bank per second.	Total discharge of river per second.	Method.	Number of velocity stations.	Number of soundings.	Direction and force of wind.
	Standard gauge.	Local.	Change in twenty-four hours.	Area.		Depth.			Width.									
				Water.	Below datum.	Mean.	Mean datum.	Maximum.										
1908.	*Feet.*	*Feet.*	*Feet.*	*Sq. feet.*	*Sq. feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Sq. feet.*	*Feet.*	*Cub. feet.*	*Cub. feet.*	*Cub. feet.*				
Apr. 6	[a]49.90	0.51	0.00	43,245	43,344	48	48.2	73.2	900	....	0.78	33,730	....	....	M.	10	67	V, light.
Apr. 7	49.92	.56	+ .02	43,590	43,644	48.4	48.5	73.2	900	+300	.93	40,725	....	....	M.	21	66	Calm.
Apr. 8	49.98	.59	+ .06	43,430	43,457	48.3	48.3	73.5	900	−187	.90	39,175	....	....	M.	17	80	Do.
Apr. 9	49.98	.62	.00	43,980	43,980	48.9	48.9	72.5	900	+523	.89	39,146	....	....	M.	17	50	Do.

[a] Red River landing. U. S. engineers' gauge. Zero is 3.57 feet above mean Gulf level.

Haskell meter, wheel No. 1, used. Constants: $a = 1.21572$; $b = +0.13312$.
The discharge section was 2 kilometers below Jonesville, La., and 30 meters above old gin at Llanada landing, and below head of Little River.
The datum line was taken at 0.62 foot on the local gauge.
For additional notes see page 121.

LITTLE RIVER, JONESVILLE, LA.

Date.	Gauges.			Cross section of discharge.						Scour or fill.	Mean velocity per second.	Discharge per second.	Discharge over bank per second.	Total discharge of river per second.	Method.	Number of velocity stations.	Number of soundings.	Direction and force of wind.
	Standard gauge.	Local.	Change in twenty-four hours.	Area.		Depth.			Width.									
				Water.	Below datum.	Mean.	Mean datum.	Maximum.										
	Feet.	Feet.	Feet.	Sq. feet	Sq. feet.	Feet.	Feet.	Feet.	Feet.	Sq. feet.	Feet.	Cub. feet.	Cub. feet.	Cub. feet.				
1903. Apr. 10		51.98		12,585		29.61		53.4	425		0.46	5,766			M.	12	88	I, light.

Haskell meter, wheel No. 1, used. Constants: $a=1.21572$; $b=+0.13312$.
The discharge section was about 150 meters from the head of Little River. The water was running upstream into lake and from there into Sabine Bayou.
For additional notes see below.

MISSISSIPPI RIVER—HYMELIA CREVASSE (928¼ R.).

Date.	Gauges.			Cross section of discharge.						Scour or fill.	Mean velocity per second.	Discharge per second.	Discharge over bank per second.	Total discharge of river per second.	Method.	Number of velocity stations.	Number of soundings.	Direction and force of wind.
	Standard gauge.	Local.	Change in twenty-four hours.	Area.		Depth.			Width.									
				Water.	Below datum.	Mean.	Mean datum.	Maximum.										
	Feet.	Feet.	Feet.	Sq. feet.	Sq. feet.	Feet.	Feet.	Feet.	Feet.	Sq. feet.	Feet.	Cub. feet.	Cub. feet.	Cub. feet.				
1903. Apr. 25		a 43.23		6,569		21.3		28.7	308		4.63	30,444			M.	4	13	

[a] The elevation of water surface above the Cairo datum plane as deduced from readings on H. W. gauges Nos. 20 and 21.

Price meter No. 40 used. Constants: $a=3.96470$; $b=+0.18146$.
The crevasse is about one-fourth mile below the St. John the Baptist and St. Charles parish line.
The river had fallen 1.8 feet from the maximum when crevasse-discharge observations were made.
No other crevasse discharges were measured during the high water of 1903 by this office.

GENERAL NOTES.—In velocity observations made with meter, the meter was run at six-tenths depth unless otherwise stated. In velocity observations made with double floats the lower one was run at mid depth. The surface float was an air-tight sheet-iron buoy, circular on plan and elliptical in cross section: axes about 5 and 10 inches. This carried a small flag. The lower float consisted of two plates of sheet iron, 10 by 12 inches, fastened together at centers, forming in plan a cross, thus, +, 10 inches high. Direction of wind is recorded as from a clock dial, XII o'clock denoting wind blowing downstream.

TABLE No. 7A.—*Meter ratings.*

HASKELL METERS.

Number of wheel.	Frame.	Date.	A.	B.	Mean error of observation.	Mean error of A.	Mean error of B.	Number of observations.	(*a*)	Length of base.	Limits of observed velocity per second.	Locality.
										Feet.	*Feet.*	
1	B.	May 20 and 22, 1902	1.20649	+0.12232				58	S.	200	0.4 to 6.9	St. Louis, Mo.
1	B.	Apr. 21, 1903	1.21572	+ .13812				32	S.	101.3	.9 to 5.1	Memphis, Tenn.
2	A.	May 21 and 22, 1902	1.85214	+ .11179				41	S.	200	.9 to 6.1	St. Louis, Mo.
2	A.	Apr. 17, 1903	1.89607	+ .05833				32	S.	200	.4 to 7.9	New Orleans, La.
[illegible]	A.	May 19, 1902	1.84926	+ .11588	±0.0668	±0.0070	±0.0158	34	R.	200	1.9 to 9.6	St. Louis, Mo.
[illegible]	A.	May 21, 1902	1.87285	+ .11640	± .0773	± .0231	± .0298	16	S.	200	1.7 to 6.2	Do.
		Weighted means	1.85124	+ .11591								
[illegible]	A.	May 22, 1902	1.83667	+ .09592	± .0775	± .0099	± .0220	37	S.	200	.5 to 9.3	Do
[illegible]	A.	Apr. 17, 1903	2.05744	+ .11364	± .0870	± .0080	± .0209	40	S.	200	.3 to 9.4	New Orleans, La.
[illegible]	A.	May 28 and 29, 1903	2.14174	+ .05815	± .0749	± .0117	± .0212	50	S.	200	1.4 to 8.1	Random Shot, Ark.
		Weighted means	2.08430	+ .08629								
11	B.	May 20, 1902	2.04935	+ .23810				40	S.	200	.8 to 8.2	St. Louis, Mo.
11	B.	May 21, 1902	2.10313	+ .26514				49	S.	200	.6 to 8.8	Do.
11	B.	May 23, 1902	2.02987	+ .19123				26	R.	200	.8 to 7.4	Do.
11	B.	Apr. 21, 1903	2.12722	+ .07638				51	S.	101.3	1.2 to 8.8	Memphis, Tenn.

PRICE METER No. 40.

Number of wheel.	Frame.	Date.	A.	B.	Mean error of observation.	Mean error of A.	Mean error of B.	Number of observations.	(*a*)	Length of base.	Limits of observed velocity per second.	Locality.
		Apr. 18, 1903	3.54601	+0.31088	±0.1650	±0.0963	±0.0568	25	S.	200	0.3 to 4.1	New Orleans, La.
		May 28 and 29, 1903	4.15712	+ .11658	± .1046	± .0653	± .0408	48	S.	200	0.2 to 4.3	Random Shot, Ark.
		Weighted means	3.96470	+ .18146								

[a] S. indicates reduction for still water. R. indicates reduction for running water.

APPENDIX 1 E.

REPORT OF ASST. ENGINEER F. B. MALTBY UPON DREDGING OPERATIONS ON THE MISSISSIPPI RIVER BETWEEN HEAD OF THE PASSES AND THE MOUTH OF THE OHIO RIVER, AND CARE AND REPAIR OF DREDGING PLANT, APRIL 1, 1902, TO MARCH 31, 1903.

MEMPHIS, TENN., *April 24, 1903.*

CAPTAIN: I have the honor to submit the following report pertaining to dredges and dredging under my direction for the period April 1, 1902, to March 31, 1903:

PROJECT.

The operations of the year include the care and repairs to plant, making tests of dredges as outlined by resolution of the committee on dredging of the Commission and made the subject of a separate report, and the field operations of the dredges in maintaining a channel 9 feet in depth and 250 feet in width from Cairo, Ill. (0), downstream as far as dredging may be necessary.

During the high-water season, when dredging is not necessary, the plant is assembled in one fleet for its care and repair. Only the necessary force to do this is retained. At the commencement of the low-water season the fleet is divided into separate plants for work, each nonpropelling dredge being accompanied by a tender, pile sinker, floating discharge pipe, and plunder barge. The self-propelling dredges do not have a towboat or a pile sinker.

Three survey parties are organized, each party being quartered on one of the small steamboats to make surveys at all shoal crossings where dredging is necessary or likely to be required. The superintendent of dredging operations is provided with a suitable boat for making frequent trips over the field covered by the fleet, so that he may inspect the working of the different parties and properly locate the dredging by personal examination of the maps and the channels themselves, all crossings being carefully sounded and surveys ordered where necessary.

CARE OF PLANT.

During the year the following plant pertaining to the improvement of the Mississippi River has been cared for at West Memphis, Ark. (234):

Dredges: *Beta*, *Gamma*, *Delta*, *Epsilon*, *Zeta*, *Iota*, *Kappa*, and *Henry Flad*	8
Steamboats: *Mississippi*, *Minnetonka*, *Sachem*, *Choctaw*, *Nokomis*, *Wynoka*, *Leota*, *Search*, *Patrol*, *Vulcan*, *Venus*, *Mercury*, and *Mars*	13
Pile sinkers: Nos. 21, 61, 971, 981, 982, 983, and 984	7
Quarterboats: Store boat No. 13, quarterboat No. 154 (Third district), and office boat *Illinois*	3
Barges: Nos. 208, 211, 215, and 228	4
Small sunk-deck flat	1
Calking flat	1

Barges Nos. 9322 and 9404, property of the first and second districts, were returned to the officer in charge on September 9 and 10, 1902, respectively.

The steamers *Mercury*, *Venus*, and *Vulcan* have been used at different times as fleet tenders during the lay-up season.

The steamer *Mississippi* returned to the fleet on April 11, 1902, having made the semiannual inspection trip of the Mississippi River Commission. This boat left the fleet again on the same mission November 1, 1902, and returned January 4, 1903; and left the fleet March 17, 1903, and on March 31, 1903, was on the return trip from New Orleans.

The steamer *Patrol* left the fleet April 1, 1902, for discharge measurements on the Cumberland River, returning to the fleet on April 11, 1902.

The steamer *Patrol*, towing the quarterboat *Illinois*, left the fleet August 19, 1902, for S. G. & O. work. The steamer *Mars* was also taken from the coal fleet at Cherokee for the same purpose. The three boats returned to the fleet December 3, 1902.

The steamer *Patrol* left the fleet March 6, 1903, for discharge work on the Lower Mississippi River, and is still in the field at the close of the period covered by this report.

The dredge *Beta*, in tow of the steamer *Sachem*, with the necessary accompanying plant, left the fleet for South Pass on May 12, 1902, and returned to the fleet December 4, 1902; it was put out of commission on December 7, 1902. The plant again left the fleet January 28, 1903, and at the close of March, 1903, was at South Pass.

A small party with the survey steamer *Mars* and pile sinker 61 left the fleet on July 2, 1902, to care for the season's fuel at Cherokee Crossing (90). This party was returned to the fleet on December 1, 1902.

The steamer *Minnetonka* left the fleet on July 29, 1902, for Cherokee, and returned on July 30, 1902, with six loaded barges of coal.

The hull of the steamer *Wynoka* was taken from the fleet on February 23, 1903, to be towed to Jeffersonville, Ind., for the erection of a new cabin.

Quarterboat No. 154 was floated onto the bank on February 27, 1903, where it will be blocked up for use as a storehouse. Quarterboat No. 13 was floated onto the bank on March 3, 1903, and will be used for the same purpose.

The steamer *Venus* left the fleet on March 12, 1903, for Columbus, Ky., to take discharge measurements, returning to the fleet on March 18, 1903, leaving on March 19, 1903, for Helena, Ark., to continue discharge work, and was still in the field at the close of the period covered by this report.

The steamer *Mercury* was transferred to Captain Lucas on March 12, 1903, for levee supply work; it was returned to the fleet on April 10, 1903. The steamer *Minnetonka* was transferred to him on March 17, and was returned to the fleet on April 1, 1903. The steamer *Mars* was transferred to him on March 18, and was returned to the fleet on April 10, 1903.

Miscellaneous.—The work of care of plant at the fleet consisted in arranging and keeping the plant in position, cleaning hulls, and checking and care of property. The unserviceable property at the fleet was condemned on May 24, 1903.

REPAIRS TO PLANT.

In addition to the more important repairs mentioned in detail in connection with various pieces of plant below, general minor repairs, such as grinding valves, repacking steam-pipe joints, painting smokestacks, tightening up and repairing propelling wheels, etc., were made where required. This class of work in the aggregate amounts to a very large amount.

Dredge Beta.—The hauling engines were entirely rebuilt and frames made of plates and angles substituted for the old cast-iron frames; journal boxes and brackets for attachment to the frames were made much heavier. The Heine water-tube boilers rested on 6-inch I-beams resting on the deck, and on account of excessive corrosion these beams had begun to show signs of weakness. The space between the bottom of the boilers and the deck and surrounding these beams was filled with concrete. A new set of shaking-grate bars for the furnaces was procured. New edge plates for the runners of the main sand pumps were put on. A new tube was put in one boiler. Feed-pump plungers were turned up and glands bushed. The nosing was repaired where necessary. The hull was scraped and painted on the inside. Minor repairs were made to the roof.

Dredge Gamma.—A new canvas roof was put on. The cabin was painted inside and out. A new slide valve and eccentric for the high-pressure cylinder was made. New edge plates for the runner of the sand pump were put on. The hauling cables were spliced. New packing rings were made for the low-pressure cylinder. A new slide valve was procured for the electric-light engine. The piston rods of the main engines were turned up and glands bushed. All bearings on the main engines were scraped and fitted. The jet engine bearings were overhauled.

Dredge Delta.—Additional stanchions were placed under the new jet pumps and steam connections made to the pumps. The hoisting rigging to the suction head was remodeled. The hull on the outside below the water line to the knuckle was sand blasted and painted and on the inside was scraped and painted. The cabin was painted on the outside and the roof was painted. New steam pipes to jet pumps were covered. Three new tubes were put in the boilers. The location of the forward closet on the boiler deck has been changed to the starboard side. A new shaft for the port winding engine has been made. A new drum for the spud hoist has been procured. New joints of lead have been put in the suction pipe from the main pump. The furnace walls have been repaired.

Dredge Epsilon.—Repairs to the main sand pump consisting of the renewal of the side plates or shroud of the runner and some parts of the lining at the throat, which were under way at the beginning of the year, were completed. Four new sheets were put in the boilers by contract. One hauling cable was spliced. The boiler feed pumps were overhauled. A new roof of asbestos was put on. A new spud was put in place. Slight repairs have been made to cabin woodwork and a new floor has been laid in the pantry and after mess room.

Dredge Zeta.—Two new sheets were put in the boilers by contract. One hauling cable was spliced. A new roof of asbestos was put on. New edge plates for the runner of the main pump were made and put on. The hauling engines were overhauled. A new floor was laid in the pantry and after mess room.

Dredge Iota.—Alterations to the suction head were completed. Extensive alterations to the main pump, contemplating placing a shroud on the runner of the main pump and converting it into one of the inclosed type, are well under way. The after ends of the boilers were raised 3 inches to make them level with the boat in working trim. Hand-holes were cut in the suction elbows of the main pump and covers made for them. New wheelhouses for the propelling wheels have been made. The closets and wash rooms on the main deck were moved and rebuilt. A screen over the breeching to protect the boiler deck from the heat was made. Derricks for handling piles were received and set up. The ice plant and electric-light engine have been thoroughly overhauled. The hot well has been abandoned and the discharge from the condenser goes directly overboard. The main steam valves over the boilers have been repaired. New brasses have been made for the main engine crossheads. The inside of the hull has been partly scraped and painted.

Dredge Kappa.—Extensive alterations to the suction head were made. New derricks for handling piles were received and set up. Four new side knee fenders were made for the main deck. Heavy timber trusses were placed under the main engines in the hold. Braces were also placed under the electric-light engine. A new engine for hoisting the suction head was received and set up. The roof was painted. The pilot house has been braced up. New traveling cranes have been built and installed over the main pump and engines. Valves and joints have been overhauled. The closets and wash rooms on the main deck were moved and rebuilt. The after ends of the boilers were raised 3 inches to make them level when the boat is in working trim. The wheelhouses were painted.

Dredge Henry Flad.—Extensive alterations were made to the suction head. New derricks for handling piles were received and set up. New engines for hoisting the suction head were received and set up. Four new side knee fenders were made. Heavy timber trusses were placed in the hold under the main engines. The roof was painted. The inside of the hull was partly scraped and painted. New travelers have been built and installed over the main engines and pump. The ice machine was thoroughly overhauled and a new piston head procured for the compressor. The pilot house has been shored up. The after ends of the boilers were raised 3 inches to make them level when the boat is in working trim. The closets and wash rooms on the main deck were moved and rebuilt. The wheelhouses were painted.

Steamer Minnetonka.—New guards aft of the forward end of the engine room and new fantails were built. The wheel was thoroughly overhauled. The hull above the water line was calked. New fire door liners were put in. The furnace was repaired. Pipes and valves were overhauled. Four new cavels were made. The roof was repaired. The inside of the cabin was painted.

Steamer Sachem.—A new tiller rope was put on; the wheel was repaired; the engines were lined up and the bearings were scraped and fitted; the boiler deck was covered with canvas and painted, and the nosing was repaired.

Steamer Chocktaw.—The furnaces were rebuilt; the engines were lined up, the bearings all scraped and fitted, and a new bottom brass for one main engine shaft bearing procured and fitted. The samson post and braces over the cylinder timbers have been extended. The boilers are undergoing extensive repairs. New steel castings for holding the truss rods on the pitmans were put on. The roof was repaired and painted. New stacks have been procured, but have not been put up. I-beams for supporting the stacks have been put in place.

Steamer Nokomis.—The port cylinder has been bored out; the engines have been lined up, and all bearings scraped and fitted. Valves and joints in the pipe lines have been overhauled. The boiler deck has been covered with canvas and painted. New stacks have been procured, but have not been put up. New pitman castings have been put on.

Steamer Wynoka.—A very small amount of work has been done, overhauling pumps and the electric light engine. New stacks have been received.

Steamer Leota.—The boilers on this boat, as well as on the others of the same type, have given trouble by the shearing of the rivets in the vertical seam. The boilers are about 30 feet long and are in two sheets, longitudinally. It was thought that these long sheets carried an excessive amount of contraction and expansion to this single seam, and to counteract this effect pieces about 24 inches long, near the center of each of the long sheets, are being cut out and new sheets put in, making five vertical seams instead of one. This work is completed on the *Leota* and well under way on the *Chocktaw* and is contemplated on the *Nokomis.* The samson posts and braces over the cylinder timbers have been extended to the roof.

Both cylinders have been bored out and new packing rings made. The engines have been lined up and all bearings scraped and fitted. The steering engine has been moved onto the main deck from under the pilot house. The roof was repaired and repainted. New stacks have been procured, but have not yet been put up. New stack supports have been put up. New pitman castings were put on.

Steamer Search.—Bulkheads converting the after part of the cabin into two rooms were built. New stumps for the stacks were procured and set up. New packing rings were made for the engines and they were lined up. Lumber for an entirely new hull has been procured. Way logs have been set on the bank and the boat floated onto them. The hull will be rebuilt when the river falls.

Steamer Vulcan.—A new wheel and new fantails have been built. The engines were thoroughly overhauled. Slight repairs were made to the woodwork where necessary. The boat has been painted all over, inside and out.

Steamer Venus.—The boat has been painted both inside and outside. The engines have been thoroughly overhauled and repairs have been made to woodwork where necessary.

Steamer Mercury.—The boat has been painted all over, inside and out. The engines have been overhauled and the woodwork repaired where necessary.

Steamer Mars.—The boat has been painted, both inside and outside. A new wheel was built. The engines and boiler were thoroughly overhauled.

Steamer Mississippi (M. R. C.).—A new wheel was built. The engines were lined up and thoroughly overhauled. The cabin has been painted, inside and out. The roof was repaired and painted. The electric-light system was rearranged and overhauled and a new switch board was installed. General and extensive repairs were made to the water-supply system. The furnaces were rebuilt and new fire-door liners and grate bars procured.

Steamer Patrol (S. G. & O.).—Only general and small repairs have been made to the woodwork.

Pile sinkers and barges.—No repairs except those of a minor nature necessary to keep them in serviceable condition have been made.

DREDGING OPERATIONS.

The project as outlined above contemplates the maintenance by dredging of a channel having a depth of 9 feet and a width of 250 feet at all stages, and manifestly the season and amount of dredging required depend to a large extent on the stage. This is true, however, only in a general sense, for within reasonable limits the depth of water in the channel depends as much on the amount and rapidity of fluctuations in stage as on the actual elevation of the stage of water at any one time. In other words, there may be, and usually is, a greater depth of water in the channel during a season of slowly falling or stationary stage, even though this stage reaches a minimum on the gauges, than during a season of short, sharp fluctuations in stage, the minimum of which may be several feet higher on the gauges. For this reason and the fact that the stage can not be forecasted the amount of dredging required in any one season can not be foretold, and the dredges assume the character of an insurance feature; they are put into the field in readiness to do such work and in such locality as is required from time to time. Generally speaking, the low-water season during which dredging may be required extends from about the middle of August to the middle of December, and the dredges, or a part of them, are usually held in commission during this time.

During the season of 1902 the first dredge to leave the fleet was the *Kappa*, on August 19. All were out of commission by December 1 except the *Beta*, which was put out of commission December 6. Dredging during the season was confined to the river between Daniels Bar (80) and Ashley Point (271). Eleven bars were dredged over, and, in addition, the tail of the bar in front of the Memphis wharf was dredged away. The greatest amount of dredging was done in what is known as the Point Pleasant country, the dredge *Kappa* being operated there throughout the season. The vicinity of Island 34, where a large amount of dredging was done in 1901, gave no trouble.

The season of 1902 was rather remarkable for the small amount of dredging required, due partly to the fact that the stage remained somewhat higher than the usual low water, and partly that the channel at the beginning of the low-water season was in better condition than ordinarily.

The following table gives a comparison of the distribution of time during the dredging season since 1898, when it might be said that dredging with an adequate plant was successfully inaugurated. The column "Actual dredging operations" includes placing plant, changing cuts, etc., as well as actual dredging:

Year.	Number of dredges in commission.	Time towing and making up tow.	Per cent of total.	Repairs.	Per cent of total.	Actual dredging operations.	Per cent of total.	Not working, waiting lower stage.	Per cent of total.	Total time in commission.
		Hours.		*Hours.*		*Hours.*				*Hours.*
1898	5	629	7.1	663	7.5	3,280	37.1	4,283	48.3	8,855
1899	5	1,232.5	10.1	1,289.25	10.6	3,831.75	31.7	5,790.50	47.6	12,144
1900	6	591	5.5	972.75	9.3	1,902.75	18.2	6,901.50	67	10,368
1901	6	713	4.7	808.25	5.3	3,586.75	23.5	10,132	66.5	15,240
1902	7	1,004.5	6.9	538.50	3.8	1,979.75	13.5	10,998.25	75.8	14,521

NOTE.—The "Total time in commission" for 1902 includes the time of the *Beta* and *Zeta*, which did no dredging.

It will be noted that the time expended in repairs shows a very gratifying tendency to decrease. The low percentage of time expended in actual dredging during the last three years is rather remarkable, and the question naturally arises whether it would not be possible to do the work required with a fewer number of dredges. Undoubtedly this would have been true in 1902, as the *Beta* and *Zeta* did no dredging and the *Epsilon* for only about twenty-six hours, and this could have been done by the *Gamma*. Ordinarily, however, this is not true, as idleness is usually caused by a rising or high stage, and as the stage falls dredging is required at all points where it is necessary at all at the same time, and it is usually impossible for one dredge to work at more than two bars within the time available to keep the channel open.

The following is a description of the work done by dredges and at each locality:

Dredge Beta.—This dredge had been employed in deepening the channel at South Pass during the summer and was not available for work under my direction till November 5, 1902, when she was received at Lake Providence, La. (542). Reports had been received of shoal water in this vicinity, and a survey was made by the party on the inspection boat *Search* on November 5, 1902. A channel 16 feet in depth was found and marked by barrel buoys. As the *Beta* was not required at any other point she laid at Lake Providence awaiting developments till November 22, 1902, when, after another examination had been made showing no necessity for dredging, she left in tow of the steamers *Sachem* and *Minnetonka* for winter quarters, arriving at West Memphis, Ark., on December 4, 1902, and was laid up.

Dredge Gamma.—This dredge, in tow of the steamers *Choctaw* and *Nokomis*, left the fleet at 9.15 a. m. on August 28, 1902, arriving at Mitchells Point (123) on August 31, and lay there till September 21, awaiting a lower stage of water. At 2 p. m. of the latter date she began dredging opposite the head of Island 20 (127), and continued dredging without interruption till 8.30 a. m. on September 25, when the work contemplated was completed. The results obtained were very satisfactory. Surveys made after dredging was completed showed a channel over 300 feet wide, with more than 9 feet in depth at standard low water.

After completion of the work at the head of Island 20 the dredge was taken to the head of Island 18 (119) and dredging opposite the head of the towhead was begun on September 29 and completed on the 30th. The operations at this point were not of great importance, as it was simply intended to remove a lump in the channel, and this was easily accomplished. The dredge lay at the bank till November 3, when dredging was resumed in the same vicinity. Dredging was completed on November 6, and on the 10th the dredge was retired from the field.

It is noteworthy that only one and one-half hours were lost for repairs on this dredge during the season.

Dredge Delta.—This dredge left the fleet in tow of the steamer *Minnetonka* on August 20 and arrived at Last Chance Crossing (166) on August 25. Dredging at this point was commenced on the 26th and continued till September 2, 1902, when the dredge went to the bank on account of the rising river. At this time there was a good, straight steamboat channel down the dredged cut of 17 feet. Dredging was resumed on the 19th and continued till the 26th, when the dredge was moved out of the cut to observe results. Eleven feet was found along the dredged cut with a stage 1 foot above standard low water. Above the end of the cut there was only 10 feet, and on the 28th and 29th this was cut out and the dredge went to the bank. This crossing gave no further trouble during the season and the channel remained in the dredged cut.

The dredge was moved to the foot of Island 34 (178) on October 1, 1902, and lay waiting orders till November 3, when it was decided that no work would be necessary at this point, and she left for Peters Crossing (270), arriving on November 4. Dredging was commenced on the 5th and continued, with minor delays only, till the 16th, when the dredge was cooled down to clean boilers. Dredging was resumed on the 18th and was completed on the 19th. On the 20th the dredge was moved to Graves Bayou (250), dredging was commenced on the 21st and was completed on the 26th, and the dredge was retired from the field.

The results obtained at each bar dredged were entirely satisfactory, and in each case a channel of the requisite depth was secured.

Numerous slight delays were encountered, owing to slight derangements of the machinery. No serious breakdown or accident occurred, but a series of aggravating incidents, which caused a total delay of eighty-eight hours for repairs. The new suction head worked fairly well, but in light of the tests made and referred to elsewhere, it is thought that the area of the opening is too large. Dredging downstream can be said to be successful, and will probably be much more so when the winding engines are made reversing.

Dredge Epsilon.—This dredge, in tow of the steamer *Nokomis*, left the fleet on September 25, 1902, and arrived at Miss Hickmans Crossing (131) on the 27th. Dredging was commenced on the 28th and completed in about twenty-four hours, when the dredge went to the bank, where she remained till November 14, when she was towed to the head of Island 20 (127), but no dredging being necessary, the dredge was retired from the field on November 18, 1902.

Dredge Zeta.—This dredge was put in commission on September 15, 1902, but did not leave the fleet, as her services were not required. She was put out of commission on October 31, 1902.

Dredge Iota.—This dredge left the fleet, under her own steam, on September 18, 1902, accompanied by the steamer *Minnetonka*, towing the pontons and a coal barge. Hathaways Crossing (103) was reached on the 22d and dredging commenced on the 24th. Dredging was continued without interruption till about noon of the 27th, when the steamer *Hermann Paepcke* ran into the dredge and broke off the port mooring pile. About 4.30 p. m. of the same day the steamer *Peters Lee* ran into the dredge and broke off the starboard pile. The ends of both hauling cables were broken off, but otherwise the dredge suffered no injury. The dredge dropped out of the channel to await results. On the 29th the channel was sounded and 13 feet found along the dredged cut and 11 feet above the end of it. The dredged cut was sharply defined, as there was only 8 feet over the bar on either side of it. Owing to a rising stage, dredging was not resumed till November 3, 1902, and continued till the 8th, when she was cooled down to clean boilers. Dredging was again resumed on the 10th and continued till the 13th, when it was abandoned on account of the stage. Dredging was again resumed on the 16th and continued till the 20th, when the work necessary was finished. The dredge was retired from the field on November 27, 1902.

The work was entirely successful, though on account of the extreme width of the river and length of the crossing it was difficult for steamboats to run in the dredged channel. Complaints were made of there being only 7 and 8 feet in the crossing, when there was not less than 11 feet in the dredged channel.

Dredge Kappa.—This dredge, under her own steam and towing her pontons, left the fleet on August 19, 1902, and arrived at Lazelles Landing (83) on the 25th. Dredging was commenced on the Tennessee side of Bixbys Towhead (83) on the 30th and continued till the 6th of September, when it was suspended on account of the rising river. Four days later there was 16 feet through the dredged channel with the stage 5¼ feet above standard low water. Dredging was resumed on the 14th and continued till the 18th, when an accident occurred to the ponton line. Repairs were made and dredging was resumed on the 21st and continued till the 24th, when, on account of another accident to the pontons, the dredge went to the bank for repairs. On account of a rising stage, dredging was not resumed till October 28, and was continued till November 2, when the dredge was cooled down to clean boilers. Dredging was resumed on the 4th and continued till the 7th, when the work necessary was completed.

The results at this bar were most satisfactory. The dredged channel was over a mile from the channel as being run when dredging began. At no time was there less than 11 feet in the dredged channel, while the old channel became impassable, the last time it was sounded there being only 7 feet and very narrow and crooked.

The record for breakdowns on this dredge was an unenviable one. On September 18, while dropping back to change cuts, the end of the ponton line was allowed to strike the bank and two universal couplings in the pipe line were broken and the third one, broken on the 24th, was probably cracked. The supports for the baffle plate were also broken. On the 20th, while pulling at a grounded barge, the port fair leads were broken. On September 16 a bolt broke in the cap of the main bearing of the main engine. On September 25 a small "bag," about 3¼ by 5¼ inches, one-half inch deep, was found in the sheet of the inboard boiler of the starboard battery. It was not a serious matter, and the bag was set up by the engineers. The boilers had been washed out only four days previously.

On November 7 the dredge went to the coal fleet at Cherokee (90) for a barge of coal, and on the return stopped at Silver Top Bar (84) to dredge out a mud lump. Dredging was commenced on the 8th and continued till the 11th. On the 10th the steamer *T. H. Davis* ran into the mooring piles and broke off both of them.

On the 13th the dredge moved to Darnells Bar (80) and began dredging, and continued till the 15th, when the work was completed. On the 14th the steamer *Polar Wave* ran into and broke off both mooring piles. On the 24th the dredge was retired from the field.

Dredge Henry Flad.—This dredge left the fleet and went to the Memphis wharf on September 22, 1902. The point of the bar above the landing had tailed down along the edge of the wharf until, at a stage below 6 feet on the Memphis gauge, boats had difficulty in reaching the paved portion with their gang planks. The ferry dock was aground and dry and it had been necessary to change the location of the ferry landing. The work of cutting away this deposit was begun on the 22d and continued, with minor interruptions caused by the character of the work, till the 30th. At that time about 600 feet of additional wharf front had been made available, with deep water up to it, and the dredge returned to the fleet to await a lower stage.

On November 5 the dredge left the fleet, downstream, arriving at Ashley Point (274) on the 6th. Dredging was begun on the same day and continued till the 9th, when the dredge was cooled down to clean boilers and replace a 6-inch steam valve over the boilers. Dredging was resumed on the 10th and continued, with various delays due to the machinery, till the 16th, when it was again cooled down to clean boilers. On the 17th an examination showed the packing rings in the port high-pressure cylinder to be broken, the cylinder badly cut and the piston rod bent. In moving the dredge to the bank a pipe in the feed-water heater gave way, and the dredge was ordered to the fleet for repairs. It arrived on the 20th and was put out of commission on the 22d.

A table (No. 8) herewith gives the distribution of time and work performed by each dredge during the season.

SURVEYS.

During the season three small parties were in the field connected with dredging operations. They were quartered on the small tenders *Venus*, *Mercury*, and *Vulcan*. Surveys were made of all bars that it was thought might become troublesome, and numerous surveys made of those bars where dredging was done to observe the effect of dredging. These surveys are of the utmost importance in giving information necessary to the intelligent location of cuts to be dredged and in studying the effect of dredging and changes in the channel. These survey parties also set buoys for the dredge masters to locate the axis of the cuts, and also to mark the steamboat channel for pilots. Fifty-nine surveys of bars were made, in which 1,262 ranges were sounded and 45,267 soundings were made, of which 11,108 were located instrumentally. In each case maps and tracings were made.

INSPECTION.

During the low-water season that portion of the river over which shoal water is known to exist is constantly patrolled by the superintendent of dredging operations on the steamer *Search*. All crossings are sounded and directions given to survey parties and to the dredging parties, and the location of all dredge cuts decided upon. In addition, supplies are carried to all the parties from Memphis, and this in itself is not a small matter. Nineteen trips were made, 7,414 miles were run, and 206,751 pounds of stores delivered to parties in the field.

During the season there was not less than 9 feet in the channel, as far as known. A table is appended (No. 10) showing the depths obtained on each trip.

In addition to the above, the gauges at New Madrid, Cottonwood Point, Fulton, Helena, Arkansas City, Greenville, and Lake Providence were inspected and such repairs made as were required. High-water gauges between Corona, Tenn., and Mhoons Landing, and the mouth of the Arkansas River and Greenville, and in the vicinity of Lake Providence, were inspected and reports on their condition made.

Tests were made to ascertain the capacity and efficiency of the dredges, and this has been made the subject of a special report.

A table (No. 9) showing in detail the cost of operation, care, and repair of the plant, covered by this report, is appended hereto.

Respectfully submitted.

F. B. Maltby,
Assistant Engineer, Superintendent Dredging Operations.

Capt. G. P. Howell,
Corps of Engineers, U. S. Army,
Secretary Mississippi River Commission.

TABLE No. 8.—*Summary of dredging operations, Mississippi River below Cairo, during low-water season of 1902.*

GAMMA.

Points of operations.	Distribution of time.									Towed.	Number of cuts.	Total length of cuts.	Average rate of advance per hour.	Average depth suction lowered.	Average depth cut.	Average steam pressure per square inch.	Averagespeed main pump, revolutions per minute.
	Placing plant.	Dredging.	Changing cuts.	Repairing.	Passing boats.	Making up tow.	Towing.	Not working; awaiting lower stage, etc.	Total.								
	Hours.	*Hours.*	*Hours.*	*Hours.*	*Hours.*	*Hours.*	*Hours.*	*Hours.*	*Hours.*	*Miles.*		*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Lbs.*	
Island 20 Crossing (127), Aug. 28-Sept. 25	2.35	81.15	4.05	....	....	5.30	74.15	507.50	675.30	109	9	7,050	88.8	17	3.3	141.2	155.5
Island 18 Crossing (120), first time, Sept. 25-30	2.30	22.25	4.40	....	....	7.10	3.45	100.00	140.30	7	10	3,400	151.6	16	2.8	140.5	156.0
Island 18 (120), lying up, Oct. 1-Nov. 2	....	....	....	....	....	....	....	792.00	792.00	....	....	....	....	....	....	....	....
Island 18 Crossing (120), second time, Nov. 3-9	2.45	28.30	3.20	1.30	....	3.00	1.00	127.55	168.00	1	8	4,625	162.3	18	3.4	140.5	156.0
Moving into winter quarters, Nov. 10-11	....	....	....	....	....	2.40	33.05	....	35.45	114	....	....	....	....	....	....	....
Total and average	7.50	132.10	12.05	1.30	....	18.20	112.05	1,527.45	1,811.45	231	27	15,075	114.1	......	3.2	....	......
DELTA.																	
Last Chance (166), first time, Aug. 20-Sept. 18	13.10	93.57	16.35	31.08	....	6.35	71.52	486.43	720.00	69	7	6,035	64.2	20	3.0	150.0	129.0
Last Chance (166), second time, Sept. 19-30	13.35	122.30	11.15	53.10	....	4.45	....	82.45	288.00	....	7	5,190	42.4	17	4.9	150.0	129.0
Last Chance (166), lying up, Oct. 1-Nov. 3	....	....	....	....	....	....	....	798.30	798.30	....	....	....	....	....	....	....	....
Peters Crossing (271), Nov. 3-19	15.25	213.20	23.45	5.20	....	2.30	28.00	103.00	391.20	90	25	24,220	113.5	20	4.4	160.0	130.0
Graves Bayou (250), Nov. 19-27	6.15	112.15	11.40	2.40	....	4.10	9.00	38.40	184.40	21	14	11,280	100.5	18	5.6	160.0	130.0
Moving into winter quarters, Nov. 27-28	....	....	....	....	....	3.30	25.00	....	28.30	20	....	....	....	....	....	....	....
Total and average	48.25	542.02	63.15	92.18	....	21.30	133.52	1,509.38	2,411.00	200	53	46,725	86.2	......	4.6	....	......

EPSILON.

Miss Hickmans (131), Sept. 25-29	3.30	17.20	5.05	4.15		5.50	55.00	29.00	120.00	101	6	8,440	198.5	16	2.2	129.0	169.0
Miss Hickmans and Last Chance (166), lying up, Sept. 30-Nov. 18							12.30	1,170.00	1,182.30	35							
Moving into winter quarters, Nov. 18							8.00		8.00	66							
Total and average	3.30	17.20	5.05	4.15		5.50	75.30	1,199.00	1,310.30	202	6	3,440	198.5		2.2		

IOTA.

Hathaways (103), first time, Sept. 18-30	2.05	50.39	4.10	76.51		7.50	87.40	82.45	312.00	137	8	7,600	150.0	15	3.6	148.0	160.0
Hathaways (103), lying up, Oct. 1-Nov. 2								792.00	792.00								
Hathaways (103), second time, Nov. 3-27	7.44	219.55	36.31	5.55				312.55	583.00		53	41,565	189.0	17	3.6	148.0	160.0
Moving into winter quarters, Nov. 27-29						3.10	47.20		50.30	135							
Total and average	9.49	270.34	40.41	82.46		11.00	135.00	1,187.40	1,737.30	272	61	49,165	181.7		3.6		

KAPPA.

Bixbys Towhead (83), first time, Aug. 19-Sept. 24	15.00	251.45	30.55	211.20		6.00	145.00	228.00	888.00	152	21	34,975	138.9	18	4.7	151.0	130.0
Bixbys Towhead, lying up, Sept. 25-Oct. 27								792.00	792.00								
Bixbys Towhead, second time, Oct. 28-Nov. 7	6.00	115.45	10.30	14.30	23.00		.30	93.45	284.00		20	20,600	178.0	17	8.6		
Silver Top Crossing (84), Nov. 8-11	1.30	43.30	2.00	17.45		2.00	11.30		78.15	13	5	3,775	86.8	14	3.1	149.0	129.0
Darnells Crossing (80), Nov. 11-24	4.00	45.15	3.15			1.30	9.80	251.45	315.15	11	9	8,100	179.0	16	3.0	150.0	130.0
Moving into winter quarters, Nov. 24-26						3.00	50.00		53.00	155							
Total and average	26.30	456.15	46.40	243.35	23.00	12.30	216.30	1,365.30	2,390.30	331	55	67,450	147.8		4.1		

TABLE 8.—*Summary of dredging operations, Mississippi River below Cairo, during low-water season of 1902*—Continued.

HENRY FLAD.

Points of operation.	Distribution of time.									Towed.	Number of cuts.	Total length of cuts.	Average rate of advance per hour.	Average depth suction lowered.	Average depth cut.	Average steam pressure per square inch.	Average speed main pump, revolutions per minute.
	Placing plant.	Dredging.	Changing cuts.	Repairing.	Passing boats.	Making up tow.	Towing.	Not working; awaiting lower stage, etc.	Total.								
	Hours.	*Hours.*	*Hours.*	*Hours.*	*Hours.*	*Hours.*	*Hours.*	*Hours.*	*Hours.*	*Miles.*		*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Lbs.*	
Memphis (230 L), Sept. 22-30, (dredging in front of wharf)	3.50	126.40	1.30	34.10		0.50	1.35	47.25	216.00	6							
West Memphis (232 R), lying up, Oct. 1-Nov. 5								847.20	847.20								
Ashley Point Crossing (274), Nov. 5-17	1.10	144.45	24.05	91.00			23.40	20.00	304.40	43	23	20,600	142.3	18	4.3	140.5	181.0
Moving into winter quarters, Nov. 18-20				45.15			20.15		65.30	43							
West Memphis, repairs, Nov. 20-22				54.30					54.30								
Total and average	5.00	271.25	25.35	224.55		0.50	45.30	914.45	1,488.00	92							

TABLE NO. 9.—*Cost of dredging operations, April 1, 1902, to March 31, 1903.*

	Labor.	Office supplies.	Subsistence.	Fuel.	Lighting supplies.	Lubricants.	Repairs.	Permanent outfit.	New plant.	Total.	Grand total.
Care of plant	$30,655.53	$242.47	$6,567.00	$6,078.58	$141.55	$286.97	$267.67				$44,239.77
Care of plant (fuel party)	1,287.23	1.50	459.66	206.06	15.62	24.75	53.42				2,048.24
Repairs to plant:											
Dredge Beta	1,021.76		211.09	26.81	3.21	.05	1,495.66			$2,758.58	
Dredge Gamma	1,081.68	.75	182.13		1.11	5.70	1,668.60			2,939.97	
Dredge Delta	2,017.16	1.10	376.11	45.82	6.86	4.49	1,539.63			3,991.17	
Dredge Epsilon	1,352.23		245.31		3.78	9.92	2,605.62			4,216.86	
Dredge Zeta	927.00		178.33		2.24	8.70	2,151.29			3,267.56	
Dredge Iota	2,978.42	.27	516.64	15.53	2.76	14.64	1,382.48			4,910.74	
Dredge Iota, pontons	64.81		11.85				.93			77.59	
Dredge Kappa	1,751.41		298.64		1.57	18.66	2,691.16			4,761.44	
Dredge Henry Flad	2,766.33	1.05	486.71		2.54	26.43	2,839.98			6,123.04	
Steamer Sachem	461.07		82.35		.27	1.75	250.63			796.07	
Steamer Choctaw	960.20	.28	163.88		.66	9.89	434.23			1,569.14	
Steamer Nokomis	566.36		106.08		.60	1.97	379.10			1,054.11	
Steamer Wynoka	980.64		46.68			1.75	142.60			1,171.67	
Steamer Leota	2,234.53		336.01	23.23	8.60	17.15	497.50			3,112.02	
Steamer Minnetonka	978.03		165.08		2.70	3.06	525.28			1,674.15	
Steamer Search	438.50		73.38		8.16	2.33	1,154.92			1,677.29	
Steamer Vulcan	609.87		118.81	23.78	.19	.59	273.31			1,026.55	
Steamer Venus	277.76		49.55		.25		217.84			545.40	
Steamer Mars	366.97		67.79		.55	1.73	277.62			714.66	
Steamer Mercury	641.76		117.62		.35	8.38	448.25			1,216.36	
Quarter boats	60.00		7.77				3.50			71.27	
Pile sinkers	252.35		45.52			7.31	175.13			480.31	
Flats and skiffs	45.00		6.39				73.75			125.14	
Tools and appliances	252.35		45.88			3.60	105.45			407.28	
Total	23,086.19	3.45	3,939.60	135.17	41.40	148.10	21,334.46			48,688.37	48,688.37
New plant:											
Dredge Kappa	251.69		45.11			.03	75.11		$156.63	528.57	
Dredge Henry Flad	251.75		48.46			.03	75.02		156.64	531.90	
Total	503.44		93.57			.06	150.13		313.27	1,060.47	1,060.47
Operations during low-water season, 1902:											
Dredge Beta	3,619.90	3.20	738.42	2,346.34	8.06	89.39	266.66			7,071.97	
Dredge Gamma	6,989.43	9.06	1,750.48	1,960.47	31.69	143.51	195.37			11,080.01	
Dredge Delta	9,310.52	9.70	2,232.38	4,103.02	53.90	258.48	385.80			16,353.20	
Dredge Epsilon	6,088.13	8.25	1,117.97	2,524.12	33.75	106.01	109.46			9,987.69	
Dredge Zeta	1,978.31	3.00	481.36	448.21	32.06	86.29	91.79			3,071.02	

TABLE NO. 9.—*Cost of dredging operations, April 1, 1902, to March 31, 1903*—Continued.

	Labor.	Office supplies.	Subsistence.	Fuel.	Lighting supplies.	Lubricants.	Repairs.	Permanent outfit.	New plant.	Total.	Grand total.
Operations during low-water season, 1902—Continued.											
Dredge Iota	$5,735.86	$7.55	$1,373.35	$3,936.77	$51.79	$824.45	$380.87			$11,810.64	
Dredge Kappa	6,585.52	10.64	1,734.68	4,836.77	78.21	350.19	304.83			13,910.84	
Dredge Henry Flad	4,606.32	8.24	1,093.97	3,288.36	25.55	151.52	277.97			9,511.93	
Steamer Search (inspection)	5,408.29	46.25	1,489.83	1,202.03	27.13	23.89	97.29			8,294.71	
Steamer Vulcan (surveys)	1,500.66	22.25	345.78	375.26	12.12	14.13	11.03			2,281.23	
Steamer Venus (surveys)	2,505.67	38.93	577.97	358.46	13.31	24.27	13.66			3,532.27	
Steamer Mercury (surveys)	1,854.82	30.14	418.42	344.73	12.72	11.08	14.37			2,686.23	
Total	56,253.43	197.21	13,354.61	25,724.54	379.69	1,533 16	2,149.10			99,591.74	$99,591.74
Buildings and grounds	91.99		18.31				121.29				231.59
Testing dredges	1,872.65		190.39	1,178.93	8.76	7.53	172.97				3,426.23
Tools, appliances, and outfit								$9,020.89			9,020.89
Grand total	113,750.46	444.63	24,623.14	33,323.28	582.02	2,000.57	24,249.04	9,020.89	$313.27		208,807.80

TABLE NO. 10.—*Depths over shoal crossings, Mississippi River, low-water season of 1902.*

Name of bar.	Miles below Cairo.	Dates of trips, 1902.								
		Aug. 8 to 9.	Aug. 16 to 18.	Aug. 21 to 24.	Aug. 26 to 30.	Sept. 11 to 14.	Sept. 14 to 20.	Sept. 22 to 25.	Sept. 27 to 30.	Nov. 1 to 8.
		Feet.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
Cairo gauge	0	20.8 to 20.3	17.7 to 16.1	15.4 to 17.1	17.4 to 18.2	15.3 to 12.6	12.9 to 9.4	8.6 to 7.4	7.6 to 11.0	13.2 to 9.7
Lesters	54	......	22	......	......	......	......	......	......	......
New Madrid gauge	70	17.8 to 17.4	[a]15	13.5 to 14.7	15.1 to 15.8	14.0 to 11.7	11.9 to 9.0	8.3 to 7.1	6.8 to 10.1	11.7 to 8.4
Nolans	76	......	22	......	......	......	......	......	......	......
Point Pleasant	81	18	18	......	......	......	......	......	......	11.5
Bixbys Towhead (new way)	83	......	......	......	......	12	......	11	13	12.5
Bixbys Towhead (Linda, old way)	83	......	11	14	......	10	......	......	......	......
Silver Top Bar	84	......	......	......	......	......	......	......	10.5	......
Cherokee	90	14	20	19	......	14	12	11	10.5	......
Little Cypress Bend (Joe Eckles)	93	......	......	......	......	......	16	......	......	......
Reelfoot	99	19	20	......	......	15	11.5	11	11	13
Hathaways	103	21	18	15	......	......	10.5	9	11	12
Booths Point, or Island 18	119	19	14	19	......	......	12	10.5	9	14
Cottonwood Point gauge	123	[a][b]15	[a][b]12.5	10.8	12.1 to 12.8	[a][b]10	[a][b]6	[b]4.5	[b]3.75	[a][b]5.25
Tylers	126	20	18	......	......	......	......	......	......	......
Head of Island 20	127	......	......	14	......	15	11.5	......	13	13
Miss Hickmans (foot Island 21)	131	22	20	17.5	......	15.5	11.5	9	9	13
O'Donnells	149	......	......	......	......	......	16	......	......	......
Gold Dust	158	21	......	17	......	......	......	12	......	......
Luxora	161	23	......	......	......	......	......	......	......	......
Plum Point (foot Island 30)	163	([c])	......	......	......	......	......	......	......	......
Last Chance	166	16.5	16	15	......	......	......	......	10	13
Fulton gauge	175	[a]14.2	[a][b]11.5	[b]10.25	11.1 to 11.8	[a][b]9.5	[a][b]6.5	[a][b]5	[a][b]4.5	[a][b]5.5
Island 34	178	18	18	16.5	......	......	11	9	9	......
Memphis gauge	230	15.2 to 14.2	11.9 to 11.0	9.7 to 9.8	10.1 to 11.0	[a][b]9.5	8.6 to 5.1	[a][b]4.75	3.2 to 3.9	[a][b]4.5
Presidents Island	234	24	......	......	18	......	14	......	......	......
Fleeces	243	23	......	......	20	......	18	14	......	......
Graves Bayou	250	23	......	......	......	......	......	......	......	......
96 Landing	......	......	......	......	17.5	......	17.5	11	......	......
Norfolk	255	......	......	......	22	......	......	......	......	......
Star Crossing	260	......	......	......	19.5	......	19	13.5	......	......
Peters	270	......	......	......	15.5	......	14	11	......	13
Ashley Point	274	......	......	......	......	......	19	12	......	......

[a] River falling.

[b] Recorded by party on steamer Search.

[c] No bottom.

APPENDIX 1 F.

REPORT OF ASST. ENGINEER F. B. MALTBY ON EFFICIENCY TESTS OF HYDRAULIC DREDGES.

During the dredging season of 1902 the following-described tests of the efficiency of the engines, boilers, and sand pumps on the various dredges belonging to the Mississippi River Commission were made. The tests were made in obedience to the following instructions, prepared by the committee on dredges and dredging of the Commission:

1. Such tests shall be made as may be necessary to determine the efficiency of boilers, engines, and sand pump of each of the dredges. The relative efficiency of the several types of jet pumps, with due consideration of the results required in economical dredging work, should also be carefully determined.

2. As a basis for determining the mechanical efficiency of engines and pumps under working load, it is necessary to first determine their frictional horsepower when running at normal speed without load.

3. The pump tests shall be made by pumping water with the intake submerged to the normal depth and the pump running at normal speed, and also at known speeds both higher and lower than the normal to ascertain the effect of variations in speed.

4. In order to ascertain as far as practicable the effect of the form of suction head, tests shall be made both with and without the suction head, where these are so attached as to be readily removable.

5. Each test shall embrace the determination of the indicated horsepower of the engines, the number of revolutions of pump per minute, the velocity of flow in suction and discharge pipe, the suction and discharge pressures.

6. In addition to the pressure gauges now in use, mercury manometers should be attached to suction and discharge pipes near the pump for the accurate determination of suction and discharge pressures.

7. The velocity of flow in suction and discharge pipes shall be carefully measured and their determinations should be made at several points in the cross section of the discharge pipe, so as to determine whether or not the whole of the discharge section is effective under normal pumping conditions. This test can, however, only be made when pumping sand; but it would not interfere materially with the regular field work if done when the dredges are in operation. Pitot tubes are recommended for use in making velocity observations.

8. The loss of head due to friction in discharge pipe shall be determined. It is also desirable to carry this investigation further, if found practicable, so as to include the effect of curved sections, rough joints, etc.

9. It is desirable to measure, as far as practicable, the relative efficiency of the double and single intake to ascertain whether the flow of two columns of water from opposite directions and meeting at the center of the pump tends to materially reduce the efficiency.

10. In conducting the above required investigations other lines of inquiry will doubtless be suggested, and if they promise results of value they should be followed up.

11. When the required observations have been completed, they shall be carefully studied and compared with a view to determine the most efficient type of engine and pump now in use and how the best of these could be improved upon in future construction.

12. The results of the above investigations shall be embodied in a report giving in detail the type and form of boilers, engines, and pumps examined and the observations made in each case, with a summary showing from the results which type or combination of types is the most efficient and best for the conditions met with in the Mississippi River.

13. It is intended that the investigations and experiments called for above will be made at such times as the dredges are not otherwise employed, as when lying at the bank waiting for suitable stage of water or at the close of the coming dredging season before being laid up for the winter. It is therefore desirable to have such preparations made in the way of instruments and measuring appliances and attachments as may be deemed necessary before going into the field.

GENERAL DESCRIPTION OF TESTS.

It was thought desirable in making these tests to obtain actual working results and to ascertain what was actually being done, rather than what it might be possible to do. With this idea in mind the tests were all made with the ordinary regular crews working in the ordinary manner. No alterations or preparations were made on the boilers or machinery except those necessary for attaching the measuring appliances.

All the plant was in good ordinary working condition, as none of it had been used to any great extent since the ordinary overhauling made during the lay-up season. The tests were made at such times as the dredges were not otherwise engaged and at such times as could be spared by the superintendent of dredging operations from his other duties.

In general the same observers were used throughout all the tests as far as practicable; all weighing scales and gauges used were carefully tested; thermometers, pyrometers, and calorimeters were of a high grade, new, and were not tested; indicator springs were calibrated.

The information and results desired, as indicated in the above instructions, may be divided under the following distinct heads and will be treated separately:

1. The efficiency and comparison of the boilers.
2. The efficiency and comparison of the main pumping engines.
3. The efficiency, capacity, and comparison of the sand pumps.
4. The effect of the form of the suction heads.
5. The efficiency and comparison of the jet pumps.
6. The loss of head in the discharge pipes due to friction and other causes.
7. The determination of the effective cross section of the discharge pipe when pumping sand.

BOILER TESTS.

In making tests of the boilers no especial preparations were made for the tests. The boilers and settings were all in good condition. The regular firemen on each dredge were used and watches changed in the usual manner. The only instructions given the firemen were to fire as regularly as possible and not to shut the draft doors, as the engineers would take care of any excess of steam generated. In nearly all cases the pumping engines and auxiliary engines were run in the ordinary manner in order that the demands on the boilers might be the same as in ordinary service. It is believed that the efficiencies obtained show fairly well the actual results obtained in regular operation.

METHODS.

The method of starting and stopping a test was as follows: The plant was operated till everything was running smoothly and regularly. The deck of the fireroom was cleaned of coal, ash pits cleaned, fire examined by the superintendent, the height of the water in the gauge glasses noted, and the word given to start the test. During the last fifteen minutes of the test the fires were closely watched by the superintendent and brought into as near the same condition as when starting the test as possible.

COAL.

The coal was what is known as "Pittsburg lump" and was taken directly from barges to the scales. No tests were made of the coal. It was all, however, practically "air dry." It was all carefully weighed on tested scales and delivered to the firemen in lots sufficient to last approximately one hour. All ashes were removed and weighed dry.

FEED WATER.

Water was pumped from the river into a cylindrical measuring tank about 3 feet in diameter and 4 feet high. It was emptied through a 6-inch gate valve near the bottom. The vertical height drawn out each time was measured by means of a large wooden float, varnished to prevent absorption of water, bearing a staff graduated to hundredths of a foot. This staff passed through a hole in a board across the top of the tank. The tank was first filled, water supply shut off, and the position of the staff read; the water was then drawn off, care being taken that the surface of the water did not go below the top of the opening leading to the discharge valve, the discharge valve closed, and the staff again read. The weight of the water per foot, as indicated by the staff readings, was determined by drawing water from the tank at various heights, observing the amount so drawn off on the staff, and weighing it on standard scales. The mean of twenty observations was used in computing the weight per foot. The measuring tank discharged into a suction tank supplying the boiler feed pump. The temperature of the feed water was measured with a high-grade thermometer at a point in the feed pipe just before entering the boilers. The height of the water in the boilers was kept constant as nearly as possible and pains taken to have it exactly the same at the beginning and end of the test. All blow-off valves and pipes and pipes from the feed pump were examined and made tight.

CALORIMETER.

The quality of the steam was determined by means of a Carpenter throttling calorimeter attached to the main steam pipe as close to the boiler as possible.

FLUE GASES.

The temperature of the flue gases was determined by two horizontal graphite pyrometers furnished by A. S. Aloe Company. They were not calibrated. They were inserted in the stacks just above the breeching.

The temperature of the feed water and readings of the calorimeter and pyrometers were taken every half hour, and the mean readings used in computing results.

Grate and heating surfaces were obtained from careful measurements of each boiler.

A table showing data and results obtained is appended hereto.

DISCUSSION OF RESULTS.

It is believed that the results on the *Gamma*, *Delta*, *Epsilon*, *Zeta*, and *Kappa* show good average working conditions and are fair examples of the efficiencies of the boilers of their class.

On the *Iota* considerable trouble was experienced in operating the engines, and for this reason it was not possible to consume the steam regularly. On the *Flad* the same difficulty was experienced, though to a less extent. The comparatively low efficiency of the latter is believed to be due to the firing, which was by far the poorest during any of the tests. The mean efficiency of the Mississippi River boilers per pound of combustible is 9.10 pounds of water evaporated, as against 9.34 for the water-tube boiler on the *Delta*. The high efficiency of the boilers on the *Gamma* is due, it is thought, to the relative large ratio of heating surface to grate surface and the high rate of combustion per square foot of grate surface. The 5-flue boilers do not seem to be more efficient than the 4-flue, and, in fact, as between the *Epsilon* and *Zeta* and the *Iota* and *Kappa* the advantage seems to lie the other way. For ease of cleaning and danger of burning the points of superiority all lie with the 4-flue boilers. The tests show that the Mississippi River type of boiler, while possessing the advantages of simplicity, ease in cleaning and repairing, is also an economical boiler in operation.

These tests also show incidentally the importance of a feed-water heater. The *Gamma* is not supplied with a heater, water from the river being pumped directly into the boilers. It will be noted that the correction applied to the quantity of water evaporated into dry steam to bring the feed water to 212 degrees is nearly 19 per cent of the total. A feed-water heater using the exhaust, which now goes to waste from the auxiliary engines, as on the *Delta*, *Iota*, *Kappa*, and *Flad*, assuming that the same temperature of feed water would be secured, would reduce this to a little over 9 per cent; or, in other words, the same amount of coal would evaporate nearly 10 per cent more water.

Sketches showing the characteristic features of the boilers and settings are appended.

EFFICIENCY OF MAIN PUMPING ENGINES.

It was not thought necessary to determine the efficiency of the engines on all the dredges, as many of them have the same general characteristics. All are engines of standard manufacture, modern, high speed, compound, and all use about the same steam pressures, the most important difference being that the *Gamma*, *Delta*, *Iota*, *Kappa*, and *Flad* are equipped with condensing engines, while the engines on the *Epsilon* and *Zeta* are noncondensing. To determine the relative efficiency of these two types, tests were made to determine the amount of water used per indicated horsepower hour by the condensing engines on the *Kappa* and the noncondensing engines on the *Epsilon*.

METHODS.

It was arranged that all the steam generated by the boilers should be used by the engines under test alone on the *Epsilon* and by the engines and condenser on the *Kappa*. Steam for operating the feed pumps and auxiliaries was furnished from an outside source. Especial care was taken to prevent leaks or to collect the drips from any that existed. The feed water was measured in the same manner as described under tests of boilers. The quality of steam was determined by the same calorimeter, attached to the steam pipe just above the cylinders. Indicators were attached to all four cylinders and cards taken simultaneously. Indicator cards and calorimeter readings were taken every half hour and the means were used in computing results.

DESCRIPTION OF ENGINES.

The engines on the *Epsilon* are "Ideal" tandem compound, a pair on each end of the main shaft of the pump. The cylinders are 16 inches and 26 inches in diameter by 18 inches stroke; piston valves on high-pressure cylinders and balanced slide valves on low-pressure cylinders. There is no receiver between the cylinders, and the cylinders have no steam jacket, but are well lagged with mineral wool. They have automatic fly-wheel governors. The normal speed is from 172 to 176 revolutions per minute, and they developed a mean indicated power of 731.82 horsepower and consumed 26.06 pounds of water per indicated horsepower hour. They were made by A. L. Ide & Sons, of Springfield, Ill.

The engines on the *Kappa* were built by the Bucyrus Company, of South Milwaukee, Wis. They are also tandem compound, direct connected to the pump shaft. The cylinders are 15½ inches and 30 inches in diameter, 24 inches stroke. High-pressure valves are of the piston type, and the low pressure balanced slide valves. The cylinders have no steam jackets, but are well lagged. They are supplied with automatic fly-wheel governors. The normal speed is about 130 revolutions per minute, and they develop a mean total horsepower of 852.01 and consume 21.42 pounds of water per indicated horsepower hour. This steam consumption includes the amount used by the condenser on the *Kappa*.

It is thought that the difference of 4.64 pounds of steam per hour per indicated horsepower in favor of the engines on the *Kappa* represents in a fair way the economy of the condensing engines over the noncondensing of this size and type. The boiler tests of the *Epsilon* show an evaporation of 7.96 pounds of water per pound of coal, or to evaporate the excess of 4.64 pounds of water per indicated horsepower hour on the *Epsilon* requires, when developing 730 horsepower, 551 pounds of coal per hour, or about 13 per cent of the total amount consumed by the dredge. This, at present prices, costs nearly $19 per twenty-four hour day for coal only, not including the cost of handling it.

A table showing in detail the data and results of this test is appended.

THE CAPACITY AND EFFICIENCY OF THE SAND PUMP.

In the design of a hydraulic dredge one of the principal features to be considered is the design of the sand pump, its efficiency and capacity, and it is evident from the resolution of the committee that the determination of the efficiencies and capacity of the various forms of pumps in use was considered the most important of the tests to be made. On the seven dredges under consideration all the pumps are of different design except on the *Kappa* and *Flad*, which are identical. The *Epsilon* and *Zeta* were originally of the same design, but the pump on the *Epsilon* has been supplied with a closed or shrouded runner, and on both the *Epsilon* and *Zeta* the number of blades has been reduced from 7 to 5. The details of each pump will be referred to later in the discussion of results.

METHODS—THE PITOT TUBE.

In determing the capacity of the pumps one of the first points to be decided upon was the method to be employed in determining the velocity of flow through the discharge or suction pipes. The instructions recommended the use of Pitot tubes. After a careful study of the subject the writer believes that there is no other simple, inexpensive, and practical method of measuring the high velocities in the 32 and 34 inch discharge pipes in use with the dredges. The publication in the Transactions of the American Society of Civil Engineers for April, 1902, of a paper on experiments on the flow of water in pipes, and especially the discussion of the original paper, was most timely. A large portion of the original paper and its discussion by members of the society is devoted to the Pitot tube, and attention is invited to it for a complete discussion of its merit as an accurate instrument for measuring the velocity of flowing water.

This accuracy seemed to be fully conceded, with tubes properly constructed, and it remained to design a tube that could be inserted readily into the suction or discharge pipes that would be strong enough to stand the rough usage it would meet and still show accurate results. All the tubes were made in the machine shops connected with the dredges, as well as the gauges with which they were connected. Nine tubes in all were constructed, but the inherent defects of the design of all but Nos. 1, 3, 8, and 9 were soon apparent and they were discarded.

DESCRIPTION OF TUBES.

A sketch of tubes Nos. 1, 3, and 8 is appended hereto.

Tube No. 1 consists of two pieces of brass tubing, one-fourth inch inside diameter, inclosed in a piece of pipe 32¼ inches long and turned to 1$\frac{5}{16}$ inches outside diameter. One of the small brass tubes is bent at its lower end, and below the end of the outside inclosing pipe, to a right angle and the plane of the opening made truly parallel with the upright pipe. This forms the impact opening or point. The other brass tube is brazed onto a solid brass piece, circular in section, and placed at right angles to the tube, the upstream end is turned down to a sharp point and its end is even with the opening in the impact point and below it; this brass point has a one-sixteenth inch hole drilled on each side, connecting with the interior of the upright brass tube, and forms the static or pressure point. The upper ends of the brass tubes have one-fourth inch air cocks, which are connected by pieces of one-fourth inch rubber tubing, about 4 feet long, to the gauges.

The small brass tubes are held in the outside tube by lead or cement poured around them. The outside tube slides through a stuffing box, which is screwed into a hole tapped in the side of the suction or discharge pipe with a 1¼-inch pipe tap. The top of the tube has a handle set carefully at right angles with the plane of the impact opening. This arrangement permits the point of the tube to be placed at any point along the diameter of the pipe in which velocity is being measured and permits "traversing," or the determination of the velocity curve across the pipe.

Tube No. 3 is very similar to No. 1, except that the impact point is below the static point.

Tube No. 8 has the same sized vertical outside pipe to permit of the use of the same stuffing boxes. At its lower end it is joined at right angles to a 1-inch pipe about 18 inches long, drawn down at the point to the size of a one-fourth inch brass tube, which is brazed into it and forms the impact point. This small brass tube runs inside the large pipe to the top, where it is provided with a one-fourth inch cock. The horizontal pipe has three one-sixteenth inch holes drilled in its side for determining the static pressure, the interior of the pipe being connected through the upright pipe and one handle to a one-fourth inch air cock. Tube No. 9 was made as nearly like No. 8 as could be done by a skilled machinist.

In the design of the tube it was thought that the fact that the impact point, when formed of a surface of revolution, will convert velocity head into static head, in accordance with the law $v=\sqrt{2gh}$, had been thoroughly proven in the discussion by Mr. W. M. White of the paper above referred to and some experiments made by him. (See Journal of the Association of Engineering Societies, August, 1901.) This point being accepted, it only remains to show that the static or pressure point of the tube used gives the true static pressure, or, in other words, that there is no suction action due to the flow of water past the static openings. If this is true, the tube will have a coefficient of unity in the formula $v=c\sqrt{2gh}$, where c is a coefficient and h is the observed difference of pressure shown by the static and impact points of the tube.

The most conclusive method of demonstrating this fact would be to rate the tube under the same conditions under which it was used, but the difficulties of rating a tube in a 32-inch pipe having a velocity of flow of from 14 to 25 feet per second and under a pressure of from 18 to 30 feet of water can readily be realized.

It is known that tubes 1 and 3 have a coefficient less than unity, but it is believed that the coefficient of tubes 8 and 9 is unity. The following observations are presented in support of this belief. The tube was rated in open running water having a velocity of about 3½ feet per second by comparing it with floats. About 80 floats were run and 600 observations were made with tube No. 9. In this case the tube was suspended in the river with the point about 12 inches below the surface and facing the current. The impact point and static point were attached to opposite ends of an inverted U tube of glass, from which the air could be partly exhausted in order to bring the water surface in the tubes high enough to be read.

The floats were 24 inches long, weighted to stand vertical in the water, and three-quarters or more of their length was submerged. The time required to pass over a course 40 feet long was observed, the tube being about one-third the distance from the upper end of the course. In the following table the velocity given by the floats is in each case the mean of ten observations and that given for the tube is the mean of about seventy-five observations.

	Velocity by float.	Velocity by tube.
No. 1	3.316	3.420
No. 2	3.284	3.279
No. 3	3.517	3.398
No. 4	3.419	3.358
No. 5	3.405	3.502
No. 6	3.212	3.228
No. 7	3.362	3.354
No. 8	3.332	3.218
Mean	3.356	3.343

The means show a coefficient of unity within about one-third of 1 per cent.

If tubes 8 and 9 have coefficients of unity they should both give the same velocity in the same pipe at the same time.

To demonstrate this they were placed in the same discharge pipe, 50 feet apart, and three sets of observations made; the position of the tubes was then reversed and three sets of observations again taken, with results as follows. Each set is the mean of ten readings.

Velocity by tube No. 8.	Velocity by tube No. 9.
25.370	24.500
24.160	25.600
25.770	25.140
[a]25.360	[a]25.190
25.370	24.840
25.550	25.020
Mean, 25.263	25.048

[a] Reversed positions.

The means agree within about eight-tenths of 1 per cent.

That the accuracy of measurements by the tubes is not affected by pressure was determined as follows:

Tube No. 8 was placed in the discharge pipe on the second ponton in the pipe line of the dredge *Epsilon*, where the average static pressure was 17.50 inches of mercury; tube No. 9 was placed in the discharge pipe on ponton No. 9, 350 feet from tube No. 8 and where the average pressure was 3.64 inches of mercury. Simultaneous readings were taken on gauges connected with each tube and at different points across the pipe.

The mean velocity determined by tube No. 8 from 170 observations was 22.321 feet per second. The mean determined by tube No. 9 was 22.351 feet per second, a difference of one-tenth of 1 per cent.

The pressure indicated by the static openings in tube No. 9 was compared with piezometers in the sides of a 32-inch pipe as follows:

Four holes were drilled and tapped for a one-fourth inch pipe on the four "quarters" of the 32-inch discharge pipe on the dredge *Kappa*, all being in the same vertical section. Care was taken to have the axis of these holes normal to the surface of the pipe. Ordinary one-fourth inch air cocks were screwed into the holes, their ends projecting inside the pipe slightly. These were afterwards filed down carefully to present a perfectly smooth surface flush with the inside of the pipe. It was thought that if there was any inaccuracy in the pressures indicated by the piezometers it would not be probable that the errors would be the same on each one, or if the pressures indicated by each piezometer were the same all would be correct. Each of the piezometers was in turn connected with every other one through a differential gauge and in no case could any difference in pressure be observed.

Tube No. 9 was then inserted into the same vertical section as the piezometers and with the point of the tube at the center of the pipe. The static side was in turn connected with each piezometer through a differential gauge and in no case could any difference of pressure be observed. The pressure given by the four piezometers and the static side of the tube was exactly the same.

This experiment, with some others taken with the point of the tube at different points along the diameter of the pipe, show, incidentally, that the pressure is the same throughout any section across a pipe and that the Bernouilli theory is not true when applied to a section.

It is conceded that the above observations do not demonstrate absolutely that the coefficient of tubes 8 and 9 is unity, but in connection with the discussion of the paper before referred to, it is believed that they furnish sufficient evidence to warrant us in assuming that their coefficient is unity, and the observations made with these tubes have been so used in reducing results.

Tubes Nos. 1 and 3 were compared with tube No. 8 by placing them in the same discharge pipe 50 feet apart. Three sets of observations of ten each were taken and the position of the tubes in the pipe reversed and three sets more taken. The results show the coefficient of tube 1 to be 0.930 and of tube 3 to be 0.8915, and these values have been used in reducing observations made with these tubes.

A brief description of the other tubes experimented with and abandoned may be of interest. A sketch is attached, showing the points only, the inclosing pipe, stuffing box and attachments for connecting with gauges being in each case similar to tubes 1 and 3.

Tube No. 2 was composed of an impact point similar to tubes 1 and 3. The pressure point was a simple vertical brass tube with the lower end open and the plane of the opening parallel with the current. This form of pressure opening showed the greatest amount of suction action of any tube experimented with. In fact, the suction was greater than the impact force on the impact point, as was evidenced by the fact that when the impact point was turned to point downstream it still showed an apparent difference of pressure, due to impact, about half as great as when pointing against the current.

Tube No. 4 was tube No. 2 with the lower end of the static point plugged up and with openings on the side.

Tube No. 5 had impact and pressure points similar, but pointing in opposite directions.

Tube No. 6 was very similar to No. 1, except that larger tubes were used, the impact point being filled with a plug having a hole one-eighth inch in diameter.

The coefficient of these tubes, except No. 6, was not obtained, as at the time they were made we were in search of a tube having a coefficient of unity and it was quite evident that these tubes did not possess that qualification.

In comparing the various tubes with each other they were at first placed in the discharge pipe 4 feet apart. It was apparent that the one lowest downstream was affected by the one above it to a very considerable extent. The distance apart was increased to 8 feet, with still an appreciable disturbance. The distance was then increased to 50 feet, and no disturbance could be detected, and the coefficients of tubes Nos. 1 and 3, as compared with tubes Nos. 8 and 9, were determined at this distance, as has been described.

THE GAUGES.

Sketches show the two different styles of gauges used.

The differential gauge is a simple U-shaped glass tube, one-fourth inch inside diameter, provided with a connection at each end for attaching rubber tubes from the Pitot tubes. The whole was securely fastened to a board, with raised edges to protect the glass from injury. A paper scale, divided into inches and tenths, was fastened to the board behind the tubes, and both the scale and board were varnished over to prevent injury from water. The open gauge was also a simple U-shaped glass tube with one leg longer than the other and with an attachment for connecting with a rubber tube at one end only. The attachments for rubber tubes were made of cast iron. The holes, where they were joined to the glass tubes, were counterbored about three thirty-seconds of an inch larger than the glass and this space filled with Portland cement, which made a most satisfactory joint. The gauges were connected to piezometers or Pitot tubes with cloth-inserted rubber tubing one-fourth inch inside diameter and not over 4 or 5 feet in length. Considerable patience and ingenuity were required to remove all the air from the tubes and the gauges above the mercury. It was found that a small amount of air in the tubes would affect the readings of the gauges quite materially, The glass tubes were not calibrated, but a careful examination revealed no appreciable difference in their size. Mercury was used in the gauges and the specific gravity was assumed to be 13.5. It is believed that the possible errors due to slight differences in the bore of the tubes or the specific gravity of the mercury are extremely small when the extreme fluctuations of the gauge readings are noted, as will appear later.

METHODS.

The measurements for determining the capacity and efficiency of the pumps and the drop in pressure in the pipe line were usually made at the same time. The latter will be referrrd to later.

It was necessary to vary the mode of procedure somewhat in the different dredges, but, generally speaking, a Pitot tube was inserted in one of the suction pipes and in the discharge pipe. The tube in the discharge pipe was placed as far from the pump as possible, to avoid the effect of the disturbance caused by it. Owing to the fact that on none of the dredges is there a piece of pipe forming the suction pipe which has any considerable length between elbows or bends of various sorts it was difficult to so locate the tubes in the suction pipes as to be beyond the effects of these bends. For this reason the velocities obtained in the suction pipes have not been used in reducing results. A piezometer was introduced in the suction pipe usually within 4 or 5 feet of the pump flange.

Piezometers were introduced into the discharge pipes at various convenient points along its length. All piezometers were one-fourth-inch air cocks, screwed into holes tapped in the horizontal center of the pipes, and were connected by short rubber tubes to gauges, already described.

Drawings submitted herewith show the position of the pumps and arrangement of pipes on each dredge: also the points where piezometers and Pitot tubes were attached.

Pitot tubes were attached to differential gauges. Indicators were attached to each cylinder of the engines.

When all was ready and the engines running regularly, the gauges were read until ten sets of readings had been taken. During this time the speed of the pump, the steam pressure, and readings of the regular spring gauges attached to the suction and discharge pipes were observed and indicator cards taken. The time required for completing a set of observations was from five to ten minutes.

These observations were made at various speeds of the pumps. The limiting speeds were fixed on the one hand by a speed so low that experience in operation had shown it to be too slow for accomplishing the most work; on the other hand, the engines were run as fast as it was thought expedient to run them without risk of injury, and in each case faster than it would be feasible to operate them regularly. The mercury in the gauges connected with both the piezometers and Pitot tubes and on both the suction and discharge pipes fluctuated very rapidly and irregularly and through an interval extending sometimes over a space of 2 or 3 inches.

At first glance it seemed impossible to read the gauges with any degree of accuracy, but by watching them closely for several moments it was seen that there was a mean position near which the mercury came to rest at short intervals. In reading, each observation was made the mean of the fluctuations as nearly as could be judged, and as each side of the gauge was read from five to ten times for each observation, it is thought that the mean is probably correct within one-tenth of an inch.

In reducing the readings of gauges connected with piezometers a correction was applied, due to the height of the mercury on the pressure side of the gauge above or below the center of the pipes, or in other words, all piezometer pressures are reduced to the pressure at the center of the pipe. In the few cases where the impact and static pressure points of the Pitot tubes were attached to separate open gauges, the readings were also reduced to give pressures at the level of the point of the tube. Where, as was usually the case, the Pitot tube was attached to a differential gauge there was no correction to be applied on account of the position of the gauge above or below the point of the tube, as the same correction would apply to each side. There was a correction to be made due to the unbalanced column of water in one leg of the gauge of a height equal to the difference of the heights of the mercury in the two legs of the gauge, or in other words, the difference of readings of the height of the mercury in the two legs of the gauge, which was apparently the height due to the pressure being observed was reduced by the weight of an equal amount of water.

The mechanical or indicated horsepower developed by the engines was obtained from indicator cards taken on all the cylinders simultaneously in the usual manner. In obtaining the total head against which the pump worked the suction head was taken from piezometer readings in the suction pipe near the pump. Readings were taken in one suction pipe of a double suction pump only, it being assumed that the suction in either pipe would be the same. Some experiments made on the *Epsilon* showed this to be practically true.

In determining the delivery head it was thought that a gauge placed close to the pump might not give the true pressures, owing to the violent disturbance in the flow. For this reason piezometers were introduced in the straight pipe and some distance from the pump. The platted line showing the fall in pressure in the pipe line referred to later on, was extended back to the flange of the pump, and this pressure corrected for any actual lift or fall in the pipe between the pump and first gauge was used for the delivery head.

If the areas of the suction pipe and discharge pipe, where measurements were made, were the same, the sum of the suction and delivery heads, as indicated by piezometers, would be the total head against which the pump was working.

This statement is contrary to the methods used, in computing the work done by the pumps, in previous tests made of the dredges and published in the annual reports of the Mississippi River Commission, and may require some explanation. In these reports the method has been, in determining total head, to take the sum of the suction and discharge heads plus the velocity head in the discharge pipe.

The total energy imparted to the water is expended, outside the pump itself, as follows: Overcoming the entrance head, friction in the suction and discharge pipes, actual lift, and creating velocity. It is generally known that on a discharge pipe flowing under pressure a piezometer will give all the head except the velocity head. On a suction pipe, however, a piezometer gives the total head including the velocity head. This fact is quite clearly shown by Mr. M. White in the Journal of the Association of Engineering Societies, October, 1900, where he proposed to and did measure velocities by means of piezometers in the suction pipes.

Some measurements made in the suction pipe of the *Delta* also showed that this assumption concerning a piezometer in the suction pipe was true. If these facts concerning the piezometers are accepted, it is evident the sum of the piezometer readings in the suction and discharge pipes gives the total head, including the velocity head, and to add the velocity head to this sum, as was done in the computations mentioned above, would be crediting the pump with velocity head twice.

On all the dredges except the *Delta* the area of the suction pipes is somewhat greater than that of the discharge pipe, and the difference of the heads due to velocity in the suction and discharge pipes has been added to the sum of the suction and discharge piezometer readings. On the *Delta* conditions are reversed, and the difference in velocity heads was subtracted from the sum of the section and delivery heads. In other words, total head, H, may be expressed

$$H=h_D+\frac{V^2_D}{2g}+h_s-\frac{V^2_s}{2g}$$

Where h_D represents head on the discharge pipe and v_D the velocity at the same point, and h_s and v_s represent head and velocity in the suction pipe.

THE VELOCITY CURVE.

All measurements of velocity for determining capacity and efficiency were taken at the center of the pipes and it was necessary to determine the relation of center to mean velocity. This was done by "traversing," or measuring the velocity at 2-inch intervals across the diameter of the pipe. This was done on each of the pipes and at the points where velocity measurements were made. All were made on a vertical diameter except on the *Iota*, where traverses were made on both horizontal and vertical diameters.

As all bends in the pipes in the vicinity of the point of application of the Pitot tubes which would affect the form of the velocity curve are in a vertical plane, it is thought that the vertical velocity curve will give the correct mean velocity.

The results of the traverses were platted on cross-section paper, and the mean velocity of each curve obtained by dividing the pipe into 10 concentric rings of equal area and taking the mean of the velocities at the centers of these rings. These curves are appended hereto; each platted velocity is the mean of ten or more observations.

The mean value of $\frac{vm}{vc}=0.8721$ for all the dredges, and it was at first intended to use this value in reducing observations on all dredges. The application of this value to results gave efficiencies widely different in cases where there was every reason to believe that approximately the same conditions existed, and on further study it was noted that although there is a variation of the value of $\frac{vm}{vc}$ from 0.8008 on the *Delta* to 0.9711 on the *Gamma*, the variation between individual determinations on any one boat seldom varies more than 2 or 3 per cent, and it was decided to use, for reducing center to mean velocities on each dredge, the ratio as determined on that individual dredge.

This value does not seem to vary in proportion with the velocity, but is probably determined by local conditions on each dredge, the proximity of bends, etc. This is especially noticeable on the *Flad*, where traverses made in the discharge pipe inside the dredge, about 110 feet from the pump and with a straight pipe from the pump, with a mean velocity of 17.44 feet per second, gives a ratio of 0.788; while a traverse made in the pipe on the first ponton, about 40 feet beyond the short reversed bends at the stern of the dredge, with a mean velocity of 14.80 feet per second, gives a ratio of 0.910. These traverses were made at different times and at different speeds of the pump.

RESULTS.

A table is appended hereto, showing data and results on each dredge and at various speeds.

The efficiency of the pump and engine as a whole is given. Efforts were made to ascertain the mechanical efficiency of the engines by obtaining the horsepower required to run them without load. The results obtained were very unsatisfactory, owing to the difficulty of obtaining satisfactory cards. None of the automatic governors would hold the engines down to a normal speed without load, and to control the speed by throttling resulted in very poor cards.

From such cards as were obtained the frictional resistance varied from about 6 per cent on the *Gamma* to about 12 per cent on the *Iota*. It may be assumed, then, that the engine efficiences are from 90 per cent to 92 per cent, and the column of pump efficiency in the table of results has been computed on a basis of 92 per cent engine efficiency.

In general, the total head against which the pump was working has increased about in proportion with the revolutions. The efficiency, compared with speed, however, varies somewhat in different pumps. On the *Gamma* the variation in efficiency between speeds of from 142 to 167 revolutions is about 6½ per cent. On the *Epsilon* the efficiencies vary very little up to a speed of 170 revolutions, when they fall off rapidly with an increase of speed beyond that point. On the *Zeta* the efficiencies increase up to a speed of 170, then they fall off. On the *Iota* there is very little difference in efficiency over the range in speed covered; on the *Kappa* the efficiency falls off regularly as the speed increases from the lowest; on the *Flad*, however, at a speed only five revolutions less than on the *Kappa* the efficiency is about 7½ per cent less, increasing to about the same efficiency as the *Kappa* at the same speed, showing that the maximum efficiency on these dredges is attained at a speed of about 120 to 125 revolutions.

Comparing the maximum efficiencies with the peripheral velocity on the different pumps, the maximum on the *Gamma* is at a velocity of 50.27 feet per second; on the *Epsilon*, 50.58 feet; *Zeta*, 51.48; *Iota*, 54.98; *Kappa* and *Flad* 45 to 48 feet. Apparently the open-runner pumps require a slightly greater peripheral velocity to obtain the maximum efficiency than those with closed or shrouded runners, but the difference is slight. Generally speaking, it would seem that a peripheral velocity of about 48 to 50 feet per second will give the best results.

It must be borne in mind that these efficiencies were obtained while pumping water, and that the deductions may not be true when pumping sand. As velocity is the vehicle of transportation, it would seem that within certain limits the efficiency as a sand pump would increase with the velocity of discharge. It is hoped to procure additional data as to the proportion of sand carried at different velocities.

The following table shows the characteristic conditions accompanying the highest efficiencies of each pump:

Dredge.	Efficiency of pump and engine.	Total head (feet of water).	Peripheral velocity (feet per second).
	Per cent.		
Gamma	71.0	26.03	50.27
Delta	56.6	34.87	44.71
Epsilon	74.1	38.68	50.58
Zeta	73.4	50.15	51.48
Iota	69.1	48.29	54.98
Kappa	71.8	38.42	43.98
Flad	74.6	48.01	48.01
Mean		40.80	49.30

RELATION OF DISCHARGE TO LENGTH OF DISCHARGE PIPE.

Especial attention is invited to the mean velocities on the *Kappa*, with 240 feet of floating discharge pipe, and the *Flad*, which had 480 feet. For the range of speeds covered on each boat, from 115 to 133 revolutions, the mean total head varies from 42.05 feet on the *Kappa* to 41.65 feet on the *Flad;* while the mean velocity, however, is 21.13 and 16.75 feet per second, respectively. With a short discharge pipe a greater proportion of the work of the pump is converted into velocity, and, as before stated, as velocity is the only means of transportation, as short a discharge pipe as possible is desirable.

The same observations apply to the *Epsilon*, with 500 feet of floating pipe, and the *Zeta*, with 1,000 feet, though as these pumps are not exactly alike the comparison can not be as rigidly made.

This point illustrates the advantages possessed by the discharge pipes belonging to the *Iota*, *Kappa*, and *Flad*, which are mounted on pontons and entirely above the water surface and can be deflected to discharge on the side of the dredged cut, while it is impossible to deflect the pipe lines belonging to the older dredges to any great extent, owing to the fact that the pipes are partly submerged. It is therefore necessary to use sufficient discharge pipe to carry the material into deep water below the end of the cut.

EFFECT OF FORM OF SUCTION HEAD.

In order to ascertain what effect the suction head has on the efficiency of the pump, it was removed on the *Gamma* and *Epsilon* and measurements taken. Very little difference, if any, in results is noted, though on the *Gamma* the efficiency seems to be somewhat higher.

On all the dredges the area of the openings in the suction heads is considerably greater than the area of the suction pipes to which they are attached, and as they contain no abrupt bends affecting the line of flow of the entering water it is not thought that the form affects the velocity.

It is believed that a head built of such form and strength as to withstand the very severe usage to which it is subjected is much more important than one of a theoretical form. It is believed, on the other hand, that the area of the openings should not exceed the area of the suction pipe, in order that the same velocity may be maintained throughout.

GENERAL COMPARISON OF PUMPS.

The table of results shows mean efficiencies of engines and pumps at what may be called normal speeds, as follows:

Dredge.	Speed (revolutions per minute).	Mean efficiency.
		Per cent.
Gamma	142 to 167	66.6
Delta	122 to 124	56.1
Epsilon	158 to 171	73.2
Zeta	159 to 171	71.2
Iota	165 to 168	68.0
Kappa	120 to 133	69.4
Flad	120 to 131	71.8

Drawings submitted herewith show the general outlines of the pumps, with their characteristic features and dimensions.

Nearly all the pumps differ in more than one particular, and it is difficult to point with assurance to any one feature as being the one which affects the efficiency to the greatest extent.

The shrouded or closed runner on the *Epsilon* has a slightly higher efficiency than the *Zeta*, which has an open runner, but otherwise of the same form and dimensions. The clearance on the *Zeta's* runners was very small, not more than one-eighth to three-sixteenths of an inch. The *Epsilon's* runner also had very little clearance, not over one-eighth of an inch. The difference in efficiency is only 2 per cent, and this is less than the difference in efficiency of the *Kappa* and *Flad*, which are identically alike, of 2.4 per cent, so that very little additional efficiency can be claimed on account of the shrouded runner.

The fact that the *Epsilon's* efficiency is greater than that of the *Kappa* and *Flad*, while even the *Zeta*, with an open runner, equals them, seems to indicate that the form of the vortex chamber and tapering runner blades on these pumps possess some advantage. These runners also have narrower blades in proportion to their diameter and also in proportion to the discharge than the *Kappa* and *Flad*

The principal characteristic of the *Gamma*, in distinction from the *Epsilon*, *Zeta*, or *Iota*, is the long curved throat opening. In fact, the curve from the suction pipe to the tip of the runner is almost continuous. Compared with the *Zeta*, which has an open runner of the same diameter, a peripheral speed approximately the same, but with an efficiency of about 4½ per cent more, it does not appear that this long throat opening possesses any advantage, and it is certainly much more expensive to make and maintain. The runner on the *Gamma* has only four blades, instead of five, as on the other pump, and this may also affect the efficiency, and probably does.

The *Delta* has the only single-suction sand pump in use on any of the dredges. Its efficiency is so much lower than any of the others as to be quite marked. The drawing of the pump shows the characteristics and dimensions. It will be noted that, besides having the distinction of being the only single-suction pump, the blades of the runners are considerably wider than the others. Which feature is responsible for the low efficiency is hard to determine. It is possible that a higher speed would have developed a greater efficiency, but it is noted that the peripheral speed is as high as the most efficient speeds on the *Kappa*, although lower than the average. The total head against which the pump was working is not greatly different from a very efficient head on the *Epsilon*, though considerably below the heads showing the greatest efficiency on all pumps except the *Gamma*. The amount of water discharged per second is approximately the same as on the *Iota*, which discharged also through the same length of discharge pipe.

Referring, then, to paragraph 9 of the instructions, we are forced to the conclusion that the double-suction pump is the most efficient and that there are no indications that the flow of the two columns of water, entering from opposite sides, tends to reduce the efficiency of the pump. It must be observed, however, that owing to the construction of the runners these two columns of water do not meet till their direction has been changed so that they are approximately parallel with each other.

A table is submitted herewith showing the efficiencies of the pumps on the *Gamma*, *Delta*, *Epsilon*, and *Zeta*, as determined in the capacity tests made in 1897 and published in the report of the Chief of Engineers for 1898. In computing this table the mean of the measured quantities given in the above report have been taken and reductions of work done, as determined by the total head, made as explained above for the present report.

In this connection it should also be observed that the former report is in error, inasmuch as in computing the weight per cubic foot of the material pumped it is assumed to weigh 62½ pounds, while in fact the mixture of sand and water weighed nearly 75 pounds in some instances. The total head should also have been expressed in feet of material pumped instead of feet of water. However, as the weight of the material pumped would be increased in the same proportion as the head would be decreased, the results would remain the same. A comparison of this table with the results of the later test shows the efficiency of the *Gamma* to be almost exactly the same in each case. This is as it should be, as the pump and engines on the *Gamma* have not been changed in any way except to keep them in repair. It also indicates that the efficiency of a pump when handling sand or water is about the same, and that we can assume that the results obtained in pumping water, in the recent tests, can be applied to the pumps as sand dredges. The *Delta* shows the lowest efficiency again, though about 8½ per cent higher than obtained in 1902. The pump and engines are the same as originally made, and the only explanation of the difference lies in the fact, as intimated above, that the speed in the later tests was too low.

The runners on the *Epsilon* and *Zeta* were of the open pattern and had seven blades in 1897 and were alike. Apparently the larger number of blades possesses a higher efficiency than the present ones of five blades.

CONCLUSIONS.

From the foregoing we are led to submit the following conclusions:

That the most efficient speed for pumps of the size under consideration is one giving a peripheral velocity of about 50 feet per second, and that the most efficient head is 45 to 50 feet.

That the closed or shrouded runner, while being a necessity, to prevent abnormal wear of the pump casings and runner, and thus increasing the clearance and decreasing the efficiency very rapidly, is also somewhat more efficient than an open runner, even with a small clearance.

That the tapering blades on the runner and curved vortex chambers are slightly more efficient, but that the additional expense of construction and maintenance is hardly warranted by the slight gain.

That the width of the blades on the *Kappa* and *Flad* is somewhat too great in proportion to the size of the pump.

That the area of the openings in the suction head, the area of the suction and discharge pipes should be approximately the same, in order that the velocity, which is the only vehicle of transportation, may be maintained at a nearly constant rate.

EFFICIENCY OF JET PUMPS OR SAND AGITATORS.

On the dredges under consideration there are installed two distinct types of jet pumps or agitators. On the *Gamma*, *Epsilon*, and *Zeta* there are single-suction centrifugal pumps with discharge pipes of 17 or 18 inches inside diameter; they deliver water to a pressure chamber just below the suction head provided with ten to thirteen jet openings 1¾ to 2 inches in diameter. The pumps are operated by a direct-connected vertical compound engine, condensing on the former and noncondensing on the two last-named dredges. In ordinary dredging operations in sand the pressure on the discharge pipe is from 10 to 15 pounds per square inch. This pressure is increased in material not readily loosened to 20 to 22 or 23 pounds, which is about the limiting pressure possible.

The dredges *Iota*, *Kappa*, and *Flad* are equipped with compound, duplex, condensing steam pumps, with 16-inch water plungers. They deliver water to a pressure chamber provided with 12 jet openings three-fourths of an inch in diameter, and are ordinarily operated at a pressure of 40 to 60 pounds per square inch. Their limit is about 80 or 90 pounds per square inch, and this pressure can not be maintained for any considerable length of time.

The table shows the results of observations made. The velocity of discharge, head, etc., for the centrifugal pumps was determined in the same manner as described under the main sand pumps. They show a combined efficiency of engine and pump of only about 41 per cent to 45 per cent, which seems quite low when compared with the larger pumps. This low efficiency can probably be explained by the fact that they have only a single suction, and there is therefore the friction of a thrust bearing to overcome, and that there is probably a greater clearance between runner and casing than on the large pumps.

In determining the efficiencies of the reciprocating pumps it was not possible to measure the velocities of flow in the discharge pipe, as the gauges and connections with the Pitot tubes were not designed for such high pressures.

The indicated horsepower was determined by indicators in the ordinary manner, but the discharge was computed from the displacement of the plungers and no allowance made for slip or leakage in the valves. This is not a very satisfactory determination, but it can readily be seen that even allowing for slip the mechanical efficiency would be considerably higher than the centrifugal pumps. It must be remembered, however, that the above efficiencies are based on indicated horsepower; and that the steam consumption with the reciprocating pump would probably be about 33 pounds per indicated horsepower hour, while with the compound engines we might expect at least as low as 24 pounds per indicated horsepower hour, so that the efficiencies when referred to the coal pile would not be so widely different.

The practical efficiency test would be the amount of work done in moving sand per indicated horsepower, and it is hoped that some tests along this line can be made later.

The writer believes the centrifugal jet pumps possess a very great advantage over the reciprocating steam pumps from a practical operating point of view, even should the latter show a greater steam economy for the same amount of work performed, for the following reasons:

No instance is recalled in the writer's experience, as superintendent for two dredging seasons, where a material was encountered by dredges equipped with centrifugal pumps that they were not as well able to handle as one equipped with the reciprocating pumps. It may be recalled that in 1898 the *Zeta* attempted to dredge through blue mud at Cherokee during a capacity test, and that her progress was very slow, the amount of material moved per hour being only about 600 yards. On the other hand, in 1902 the *Kappa* attempted to cut out a mud lump at Silver Top Bar, and an advance of only 50 feet per hour could be made, cutting less than 8 feet in depth and in a very strong current. The jets in this material seemed to have no effect whatever.

The centrifugal jet pumps are extremely simple, contain no valves, and require no repairs, and practically no attention. The centrifugal pump on the *Gamma* ran for five seasons without even being taken apart for examination, and then the runner and casing showed no wear, the scale not even being worn off. The total repairs made consisted of a new brass bushing in the bearing of the shaft.

I think that the repairs of these pumps on the *Epsilon* and *Zeta* have not been more elaborate. The care and repair of the engines connected with them is not greater than that required for the steam end of the reciprocating pumps. The latter pumps, on the other hand, are a constant source of labor and expense in care and repair. It requires 120 feet of 1-inch square flax packing to pack the plungers on each of the pumps on the *Kappa*, *Flad*, or *Iota*, and this packing must be renewed at least once each season and more if a great deal of dredging is done.

The jet pumps on the *Delta* contain 260 hard-rubber valves, which required grinding on each side three times during the season of 1902, during which time five hundred and thirty-two hours were consumed in dredging, or, in other words, the valve surfaces required repair after a little less than four days' use. An entire set of new valves will be required for the next season. This example is an extreme one, though a large number of valves on the other pumps require renewal every year. The pumps require constant attention and care, keeping packing tight, etc.

THE LOSS OF HEAD DUE TO FRICTION IN DISCHARGE PIPE.

An inspection of the table of results shows that the delivery head is a very large proportion of the total head against which the pumps were working, amounting, on the *Gamma*, *Delta*, *Epsilon*, and *Zeta*, where discharge pipes are nearly horizontal from the pumps, from about 55 per cent to 60 per cent with 500 feet of floating pipe, from 70 per cent to 75 per cent with 1,000 feet. On the *Iota*, *Kappa*, and *Flad* this varies from about 60 per cent to 75 per cent, but on these dredges it includes, besides the loss by friction, an absolute lift of about 5 feet at the gooseneck at the stern of the dredge.

The loss in head was determined in the following manner: Holes were drilled in the suction and discharge pipes on the horizontal center and tapped for one-fourth inch pipe thread, and into these holes were screwed ordinary commercial one-fourth inch air cocks. The hole in these cocks at the screwed end is about one-fourth inch in diameter and is reduced through the plug and at the outlet end to about three-sixteenths of an inch. Short pieces of rubber tubing connected the cocks with gauges, already described, which rested on top of the pipes or in other convenient positions. Gauge readings were in each case corrected for the height of the gauge above or below the piezometer to give the true pressures at the center of the pipe.

The positions of the piezometers along the pipe lines are shown in the accompanying sketches.

Circumstances were such that it was impossible in most cases to go inside the pipes and ascertain if the ends of the cocks were exactly flush with the inside of the pipe, but from the known thickness of the pipe and length of thread on the shank of the cock they could be screwed in till they were approximately flush.

In connection with the comparison of the static pressure indicated by tube 9 and four piezometers placed on a vertical section and filed smooth with the inside of the pipe mentioned in the discussion of the Pitot tube four piezometers were placed in a vertical section 5 feet downstream from the first set. These were put in in the ordinary manner as described above, and each of the eight connected to open gauges and readings taken at the same time.

The mean of twenty observations of gauges connected to the four piezometers in the first set showed a pressure of 6.01, 6.05, 6.02, and 6.16 inches of mercury, respectively, a mean of 6.06, while the pressures indicated by the piezometers in the second set were 5.74, 5.35, 4.53, and 5.26 inches of mercury, respectively, a mean of 5.22. Correcting this for the drop in pressure in 5 feet of pipe, which in this case amounts to 0.25 inch of mercury, gives a means of 5.47, or 0.59 inch of mercury as the error. This error will always be in one direction and probably very nearly constant, so that relatively the indicated drop in pressure in a pipe line will not be far from correct.

The effect on the determination of the total head against which the pumps work would be to make it too small and the efficiency of the pumps too low. As the delivery head has been obtained in each case, as already explained, by a combination of piezometers on the discharge pipe, it is thought that the error on this account will not exceed 2 or 3 per cent.

It will be observed that the above observations on the first set of piezometers do not agree as well as those mentioned in comparison with the Pitot tube, where each one was in turn connected with every other one through a differential gauge and all gave exactly the same pressure. The explanation is probably to be found in the fact that these latter measurements were made on open gauges and the variations in pressure are due to errors in gauge readings due to extreme fluctuations, as mentioned before, and especially as efforts were made to read these gauges at exactly the same instant, instead of, as was usually the case, reading the gauges over a given period of time and attempting to get readings of mean fluctuations. On the other hand, the differential gauge was very steady when attached to two piezometers. The fluctuations hardly extended over more than one-tenth of an inch, and three experienced observers were not able to detect any preponderence of pressure in favor of one side over the other.

Diagrams are submitted herewith on which the observed pressures on the discharge pipe at various points along its length have been platted for each dredge and at various speeds. These diagrams also show in dotted lines how the delivery head at the pump was obtained, as referred to under the efficiency of the pumps.

The *Gamma*, *Delta*, and *Zeta* show a fairly uniform drop from the stern of the dredge along the pipe line. On the *Gamma* and *Delta* the drop from the last gauge inside the dredge to the first one on the pipe line is not uniform with the rest of the line owing to a change in diameter of pipe inside and outside the dredge. The drop is also complicated inside the *Delta* by an absolute drop in the elevation of the pipe. On these dredges the pipe line was very nearly straight, and there was very little leakage at the connecting joints. The drop in pressure was not observed on the *Epsilon*, and the delivery head was obtained from observations on one gauge and extending the line of drop back, as indicated on the *Zeta*.

The *Iota*, *Kappa*, and *Flad* show interesting indications of the effect of short, abrupt bends on the loss of head. On each of these dredges there is a reversed bend at the stern of the dredge, the effect of which is shown in the drop between the last gauge on the dredge and the first one on the pontoons. This drop on the *Iota* is from 9.5 to 12 inches of mercury. This amount may be partly accounted for by an absolute lift of 5 feet, or 4.4 inches of mercury, and a drop of about 2.8 inches, due to the horizontal distance between gauges, leaving the loss of head due to the bends of from 2.3 to 4.8 inches of mercury, or from about 10 per cent to 16 per cent of the total delivery head.

On the *Kappa*, with a shorter discharge pipe, the effect of the short bends is more marked, the net loss being 7.1 inches, or 25 per cent of the total delivery head. On the *Flad* this loss amounts to about 2.4 inches, or a little less than 10 per cent.

There is also shown the increase in the suction due to the reversed curves in the suction pipe of the *Delta*. In this case the pipe on each side of the curves was about on the same level, as the bends are horizontal. The difference, then, of about 7 inches, or more than 50 per cent of the total suction head, is nearly all due to the bends. It does not seem to require any further argument as to the undesirability of short bends in the pipes.

The upper line on the diagram of the loss of pressure on the *Flad* shows the additional load caused by deflecting the pipes at each joint to the limit of their throw—about 20°—indicating that the loss due to slight bends, all in the same direction, is not great.

THE EFFECTIVE CROSS SECTION OF THE DISCHARGE PIPE AND PROPORTION OF SAND PUMPED.

Paragraph 7 of the resolution of the committee instructed that the velocity of discharge should be measured at several points in the cross section of the pipe, while pumping sand, to determine the effective cross section.

During the progress of the experiments already described we were not successful in determining the velocity of discharge while pumping sand, but were successful in determining the effective cross section, and several determinations were made of the proportion of sand carried.

The apparatus devised was as follows: A piece of 1-inch pipe, about 4 feet long, was fitted to go through one of the stuffing boxes already described as used with the Pitot tubes; the lower end of the pipe was bent to a right angle to face the current; the upper end of the pipe was fitted with two elbows, so arranged as to turn the opening downward; between the elbows was a gate valve for shutting off the flow of water. The fittings on the top of the pipe formed a handle, by means of which it could be manipulated. The stuffing box permitted the lower end of the pipe to be placed at any point along the vertical diameter at the point of application.

The lower end of the pipe being made to face the current and the valve being opened, the water would flow into the lower end and out at the upper end, as the vertical height of the pipe was much less than the head on the pipe at that point, and it was assumed that this stream of water would carry the same proportion of sand as was being carried in the discharge pipe at the point of the tube.

The water and sand issuing from the pipe were caught in iron buckets and tin cans and the proportional part of sand was measured. No attempt was made to determine the sediment or mud in suspension, but only that portion of the material which settled to the bottom of the receptacle at once or, say, within a minute. These measurements were made at intervals of 2 inches along the diameter. Three sets of traverses were made on the *Delta* while dredging at Peters Crossing and eight on the *Kappa* in the chute of Presidents Island, and tables are submitted herewith showing results.

The evidence that the whole cross section of the pipe is effective is quite conclusive, as in no case was there any evidence that any sand was resting on the bottom of the pipe, as the small pipe was shoved down to the bottom in every set of observations.

The indicated proportion of sand carried varies widely, and from the nature of the work it must be true that the actual proportion of sand being carried varies constantly. It can not be assumed that sand flows in a constant, uniform stream into the suction head, and in fact we know very well that it does not do so. It will therefore be necessary to take a large number of observations to determine with accuracy what proportion of sand is carried.

The results of the three sets of observations on the *Delta* have been platted and the mean of the eight sets also platted. Two of the sets on the *Delta* were taken dredging downstream; the mean amount shows 14.4 per cent sand, while the mean dredging upstream is 28.4 per cent sand. This is explained by the fact that in dredging downstream the only power available for moving the dredge is the force of the current. The dredge can not be forced into a bank of sand, as is possible in dredging upstream. The mean of all observations on the *Kappa* is 16.9 per cent of sand carried. The mean platted line of all results shows that the proportion generally increases from the top toward the bottom; though the table shows, in one instance at least, a greater proportion near the top than near the bottom. The proportion varies from 3 per cent to 46 per cent.

These measurements were made experimentally and near the close of the season, when very little time was available. They are not submitted as conclusive evidence, and it is hoped that more measurements can be made and that at the same time the velocity can be determined and thus determine the relation of velocity to sand-bearing capacity.

It will be noted that on the diagrams showing the loss of pressure on the *Iota*, *Kappa*, and *Flad* the point of zero pressure is at the last gauge, or about 30 feet from the end of the pipe, instead of at the end of the pipe, as would be expected. An explanation of this fact is not attempted by the writer at present, but that it was a fact on all three dredges is beyond doubt, as the observations were tested in various ways.

When the piezometer was connected to the ordinary mercury gauge it showed no pressure nor suction; the mercury would occasionally fluctuate from 0.05 inch above zero to an equal distance below. The mercury was then poured out of the gauge and it was filled with water to the height of the piezometer, and it still showed no pressure and no suction, though the water in the glass would occasionally fluctuate one-half inch above or below the zero.

The gauges were then removed and the air cock unscrewed from the hole in the pipe. This hole is one-half inch in diameter; but although it was on the horizontal center of a 32-inch pipe flowing entirely full and at a mean velocity of from 14 to 21 feet per second, no water came out except occasionally a few drops, which seemed to be caught on the downstream edge of the hole and thrown out. This observation was made on each of the three dredges mentioned above. How far from the end of the pipe the condition of no pressure extended was not determined. The fact is only true when the pipes were flowing entirely full at the ends. When on the *Iota* the speed of the pump was reduced to such an extent that the water filled the discharge pipe at the end to within 4 or 5 inches of the top, then the water in the gauge attached to the piezometer rose to approximately the height of the water in the pipe, as in an open channel.

After the capacity tests had been completed the Commission secured the services of Prof. W. B. Gregory, of Tulane University, to "examine the results obtained and suggest if any further measurements were desirable." No additional capacity tests were made, but some of the observations in connection with the Pitot tube, mentioned above, were made at his suggestion. I am also indebted to him for suggestions as to the reduction of final results.

Asst. Engineer William Gerig rendered valuable assistance in making observations, and the final reductions and computations were nearly all done by him.

Very respectfully submitted.

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Capt. Wm. B. Ladue,
Corps of Engineers, U. S. A.,
Secretary Mississippi River Commission.

Table of percentage of sand handled by Delta, Peters Crossing, November, 1902.

Distance from top of pipe.	1. Dredging upstream.	2. Dredging down-stream.	3. Dredging down-stream.
	Per cent.	*Per cent.*	*Per cent.*
4 inches	0.143	0.047	0.125
6 inches		.047	.111
8 inches	.177	.048	.117
10 inches		.058	.080
12 inches	.226	.089	.083
14 inches		.094	.200
16 inches	.276	.094	.175
18 inches	.267	.117	.176
20 inches	.243	.100	.141
22 inches	.286	.125	.235
24 inches	.304	.187	.187
26 inches	.321	.187	.141
28 inches	.358	.187	.219
30 inches	.371	.187	.250
32 inches			.250
33 inches (bottom)	.437	.250	
Mean	.284	.121	.166

Average of columns 1, 2, and 3, 0.190 per cent.

Table showing percentage of sand handled by Kappa, Presidents Island, November 28 and 29, 1902.

Distance from top of pipe.	1.	2.	3.	4.	5.	6.	7.	8.	Mean.
Top	0.031	0.067							
2 inches	.281	.193	0.125	0.125	0.088	0.100	0.063	0.030	0.126
4 inches	.255	.080	.140	.155	.125	.100	.063	.063	.123
6 inches	.271	.099	.125	.105	.125	.125	.083	.188	.140
8 inches	.207	.118	.155	.188	.150	.250	.125	.188	.172
10 inches	.247	.129	.155	.220	.125	.125	.125	.168	.162
12 inches	.060	.147	.188	.220	.188	.168	.083	.125	.146
14 inches	.110	.135	.188	.235	.214	.168	.188	.088	.166
16 inches	.078	.152	.155	.205	.175	.188	.167	.125	.155
18 inches	.214	.125	.250	.220	.171	.205	.083	.168	.167
20 inches	.147	.119	.188	.313	.168	.250	.083	.125	.174
22 inches	.131	.138	.188	.280	.168	.168	.125	.168	.171
24 inches	.177	.214	.280	.250	.188	.125	.125	.125	.185
26 inches	.130	.193	.280	.225	.179	.125	.125	.188	.181
28 inches	.137	.339		.219	.174	.168	.125	.125	.198
30 inches	.171	.467		.250	.168	.125	.125	.125	.204
Bottom, 32 inches				.250	.250	.188	.250	.250	.238
Mean	.165	.169	.186	.216	.168	.161	.121	.141	.169

The material was ordinary channel sand, possibly slightly finer than the average, pumped through 240 feet of 32-inch discharge pipe.

The measurements were made at the center of the second pontoon, or about 100 feet from the stern of the dredge.

Data and results of feed-water test of engines.

Description of main pumping engines.	Dredge Epsilon.		Dredge Kappa.	
Date of and duration of test	Dec. 9, 1902, 7 hours.		Dec. 17, 1902, 6 hours.	
Engines, pair of tandem compound direct connected	Noncondensing.		Condensing.	
Dimensions of engines:	*H. P.*	*L. P.*	*H. P.*	*L. P.*
Bore ... inches	16	26	15½	30
Stroke ... do	18	18	24	24
Diameter piston rods ... do	2¼	3¼	2 9/16	3½
Diameter tail rods ... do	....	3¼	....	3½
Average clearance, per cent of volume displaced by piston	....	....	....	....
Horsepower constant $\frac{1a}{33000}$:				
Crank end	0.008916	0.023756	0.010576	0.042257
Head end	0.009139	0.023910	0.010889	0.042527
Mean effective pressure starboard engine:				
Crank	71.04	15.32	61.60	15.90
Head	70.78	15.00	57.31	18.53
Mean effective pressure port engine:				
Crank	79.99	16.63	83.86	22.74
Head	79.82	16.58	83.41	24.18
Mean steam pressure at throttle valve	128.4	....	150	....
Mean vacuum on condenser	....	....	21.7	....
Mean revolutions per minute	172.7	....	129.8	....
Mean indicated horsepower starboard engines	221.12	124.83	166.86	189.50
Mean indicated horsepower port engines	249.16	136.71	237.34	258.31
Mean total indicated horsepower per hour	731.82		852.01	
Total weight of water consumed, corrected for leaks	136,870.990		111,970.602	
Percentage of water in steam	2 1/10		2 2/10	
Total quantity of dry steam consumed	133,507.199		109,507.249	
Weight of dry steam used per hour	19,072.457		13,251.208	
Weight of dry steam per indicated horsepower per hour	26.06		21.42	

NOTE.—The above amount of steam used includes, on the *Kappa*, that used in the condenser, which is a compound duplex noncondensing jet condenser.

Results of boiler tests, 1902

	Dredge Gamma.	Dredge Delta.	Dredge Epsilon.	Dredge Zeta.
Date	Oct. 6, 1902.	Sept. 18, 1902.	Oct. 7, 1902.	Oct. 21, 1902.
Duration of trial	12 hours.	12 hours.	12 hours.	12 hours.
Type of boiler	3-5 Flue Miss.	3 Heine.	6-5 Flue Miss.	6-5 Flue Miss.
Grate surface ... square feet	61.75	107	154	154
Water-heating surface ... do	1,845.5	6,120	3,879	3,879
Ratio of grate to heating surface	1-29.8	1-57	1-25	1-25
Average steam pressure	135.2	148.6	124.1	133.4
Average temperature of feed water entering boilers	73.7	188.3	183.2	191
Temperature of stack gases	573	788.6	599	667
Percentage of moisture in steam	1.2	1.05	1.2	1.4
Total amount of coal consumed, pounds	18,651	29,718¼	39,220	40,414
Total amount of refuse, dry, pounds	642	1,657¼	2,999	2,650
Total amount of combustible	18,009	28,061	36,221	37,764
Coal consumed per hour	1,554	2,476.5	3,268.3	3,367.8
Coal consumed per hour per square foot, grate surface	25.16	23.1	21.2	21.8
Coal consumed per hour per horsepower	3.3	4.0	4.3	4.1
Total amount of water pumped into boilers and apparently evaporated, corrected for difference of level, etc	163,044	246,503	293,915	319,865
Water actually evaporated, corrected for quality of steam	161,087	243,915	290,388	315,387
Equivalent water evaporated into dry steam from and at 212°	191,693	261,965	312,167	336,833
Equivalent water evaporated into dry steam from and at 212° per hour	15,974	21.830	26,014	28,069
Equivalent water evaporated into dry steam from and at 212° per pound of coal	10.27	8.81	7.96	8.33
Equivalent water evaporated into dry steam from and at 212° per pound of combustible	10.64	9.34	8.61	8.92

Results of boiler tests, 1902—Continued.

	Dredge Gamma.	Dredge Delta.	Dredge Epsilon.	Dredge Zeta.
Equivalent water evaporated into dry steam from and at 212° per square foot of heating surface per hour	8.65	8.56	6.70	7.24
Equivalent water evaporated into dry steam from and at 212° per square foot of grate surface per hour	258.70	204.01	168.92	182.26
Commercial horsepower developed, based on the evaporation of 34½ pounds of water from and at 212° per hour	463	682.7	754	813.5

	Dredge Iota.	Dredge Kappa.	Dredge Flad.
Date	Sept. 17, 1902.	Oct. 18, 1902.	Oct. 3, 1902.
Duration of trial	9 hours.	12 hours.	9.083 hours.
Type of boiler	7-4 Flue Miss.	7-4 Flue Miss.	7-4 Flue Miss.
Grate surface ... square feet	157.5	157.5	157.5
Water heating surface ... do	3,760	3,830	3,830
Ratio of grate to heating surface	1-23.9	1-24.3	1-24.3
Average steam pressure	150	161	141
Average temperature of feed water entering boilers	168	161	171
Temperature of stack gases	681	502	678
Percentage of moisture in steam	0.75	1.45	2.5
Total amount of coal consumed ... pounds	21,189	35,535	29,183
Total amount of refuse, dry ... do	1,639	1,177	826
Total amount of combustible	19,550	34 358	28,357
Coal consumed per hour	2,354.3	2,877.9	3,212.9
Coal consumed per hour per square foot grate surface	14.9	18.2	20.4
Coal consumed per hour per horsepower	3.9	3.8	4.5
Total amount of water pumped into boilers and apparently evaporated, corrected for difference of level, etc	170,325	288,224	209 253
Water actually evaporated, corrected for quality of steam	169,048	284,045	204,022
Equivalent water evaporated into dry steam from and at 212°	185,108	313,444	222,568
Equivalent water evaporated into dry steam from and at 212° per hour	20,568	26,120	24,504
Equivalent water evaporated into dry steam from and at 212° per pound of coal	8.73	8.82	7.63
Equivalent water evaporated into dry steam from and at 212° per pound of combustible	9.47	9.12	7.85
Equivalent water evaporated into dry steam from and at 212° per square foot of heating surface per hour	5.46	6.78	6 40
Equivalent water evaporated into dry steam from and at 212° per square foot of grate surface per hour	130.50	165.84	155.58
Commercial horsepower developed, based on the evaporation of 34½ pounds of water from and at 212° per hour	5.96	7.57	710.2

TESTING DREDGES.

Data and results of main-pump tests, 1897.

Name of dredge.	Revolutions per minute.	Steam pressure.	Vacuum inches mercury.	Total indicated horsepower.	Suction pipes.				Discharge pipe			
					Inside diameter.	Area.	Mean velocity per second.	Velocity head feet of water.	Inside diameter.	Area.	Mean velocity per second.	Velocity head feet of water.
		Lbs.			*Ins.*	*Sq. ft.*	*Feet.*		*Ins.*	*Sq. ft.*	*Feet.*	
Gamma	168.2	141.6	25.52	485.37	24¾	6.682	9.115	1.29	34	6.305	9.660	1.45
Delta	150.8	157.9	23.33	1,039.6	33¾	6.212	15.107	3.55	34¼	6.492	14.455	3.25
Epsilon	181.6	159.4	......	748.92	24¼	6.414	14.566	3.30	32¼	5.673	16.468	4.22
Zeta	181.4	146.2	......	686.94	24¼	6.414	14.343	3.20	32	5.585	16.472	4.22

TESTING DREDGES—continued.

Data and results of main-pump tests, 1897—Continued.

Name of dredge.	Discharge per second.	Discharge per second.	Heads feet of water.				Work done per second.	Efficiency of pump and engine.
			Suction.	Delivery.	Velocity.	Total.		
	Cu. ft.	*Pounds.*					*Ft. lbs.*	*Per cent.*
Gamma	60.907	3,806.69	9.38	37.0	0.16	46.54	177,163.35	66.4
Delta	93.845	5,865.31	18.62	45.54	−0.30	63.86	374,558.70	65.5
Epsilon	93.424	5,839.00	17.2	36.9	0.92	55.02	321,261.78	77.9
Zeta	91.996	5,749.75	11.52	35.1	1.02	47.64	273,918.09	72.5

NOTE.—These efficiencies are obtained by using the mean quantities measured, as given in Report of Chief Engineers, 1898, and reducing results by same methods as used in tests of 1902.

Data and results of main pump tests, 1902.

Name of dredge.	Revolutions per minute.	Steam pressure.	Vacuum mercury.	Total indicated horse-power.	Suction pipes.				Discharge pipe.	
					Inside diameter.	Area.	Mean velocity per second.	Velocity head of water.	Inside diameter.	Area.
		Lbs.	*Inches.*		*Inches.*	*Sq. feet.*	*Feet.*	*Feet.*	*In.*	*Sq. feet.*
Gamma	142	138	22.0	297.47	24¾	6.682	12.982	2.62	34	6.305
	154	147	22	356.91	24¾	6.682	13.680	2.90	34	6.305
	160	139	22	407.93	24¾	6.682	14.395	3.22	34	6.305
	167	145	22.5	457.61	24¾	6.682	15.007	3.50	34	6.305
	153	147	22.5	351.74	24¾	6.682	13.600	2.87	34	6.305
	154	142	22.5	352.94	24¾	6.682	13.870	2.90	34	6.305
Delta	122	160	23	737.39	33¾	6.212	17.452	4.73	34½	6.492
	122	162	23	737.89	33¾	6.212	16.965	4.47	34½	6.492
	124	165	23	784.15	33¾	6.212	17.784	4.92	34½	6.492
Epsilon	158	144	....	587.50	24¼	6.414	17.554	4.79	32¼	5.673
	165	139	....	680.70	24¼	6.414	18.482	5.31	32¼	5.673
	166	141	....	687.92	24¼	6.414	18.356	5.23	32¼	5.673
	168	123	....	712.67	24¼	6.414	18.755	5.46	32¼	5.673
	171	140	....	765.97	24¼	6.414	19.088	5.66	32¼	5.673
	181	133	....	874.69	24¼	6.414	19.513	5.91	32¼	5.673
	181	133	....	867.41	24¼	6.414	19.441	5.76	32¼	5.673
Zeta	150	132	....	483.85	24¼	6.414	12.321	2.36	32	5.585
	159	134	....	571.15	24¼	6.414	13.067	2.65	32	5.585
	170	126	....	690.40	24¼	6.414	14.234	3.15	32	5.585
	171	125	....	712.06	24¼	6.414	14.304	3.18	32	5.585
	175	129	....	734.07	24¼	6.414	14.347	3.20	32	5.585
Iota	151	155	23	667.69	24	6.283	16.016	3.99	32 11/16	5.828
	165	150	24.8	817.83	24	6.283	16.622	4.29	32 11/16	5.828
	165	150	25	817.83	24	6.283	16.862	4.42	32 11/16	5.828
	165	150	25	817.83	24	6.283	16.751	4.36	32 11/16	5.828
	168	146	25.2	867.54	24	6.283	17.393	4.70	32 11/16	5.828
	168	146	25.2	867.54	24	6.283	17.393	4.70	32 11/16	5.828
Kappa	120	120	20	662.03	24¼	6.414	16.986	4.48	31⅞	5.541
	123	146	20.3	744.80	24¼	6.414	17.893	4.98	31⅞	5.541
	126	153	20	793.49	24¼	6.414	18.130	5.11	31⅞	5.541
	126	160	20	797.19	24¼	6.414	18.114	5.10	31⅞	5.541
	127	165	19.2	817.70	24¼	6.414	18.508	5.32	31⅞	5.541
	129	165	20	844.85	24¼	6.414	18.552	5.35	31⅞	5.541
	132	160	20	885.95	24¼	6.414	18.808	5.50	31⅞	5.541
	133	165	20	926.34	24¼	6.414	19.079	5.66	31⅞	5.541
Henry Flad	115	152	17	537.35	24¼	6.414	12.869	2.57	32	5.585
	115	139	15	521.53	24¼	6.414	12.869	2.57	32	5.585
	120	145	14.5	590.61	24¼	6.414	14.586	3.31	32	5.585
	126	123	20	634.98	24¼	6.414	14.796	3.40	32	5.585
	129	116	21	645 58	24¼	6.414	14.767	3.39	32	5.585
	129	117	21	644.31	24¼	6.414	14.898	3.45	32	5.585
	131	137	14	782.68	24¼	6.414	16.665	4.32	32	5.585
	128	137	18	701.29	24¼	6.414	15.249	3.62	32	5.585

Data and results of main-pump tests, 1902—Continued.

Name of dredge.	Discharge pipe.			Discharge per second.	Discharge per second.	Heads, feet of water.			
	Center velocity per second.	Mean velocity per second.	Velocity head of water.			Suction.	Delivery.	Velocity.	Total.
	Feet.	*Feet.*	*Feet.*	*Cu. feet.*	*Pounds.*				
Gamma	14.170	13.760	2.94	86.757	5,422.31	7.09	12.54	0.32	19.95
	14.930	14.499	3.27	91.416	5,713.50	7.90	13.90	.37	22.17
	15.710	15.256	3.62	96.189	6,011.81	8.75	15.36	.40	24.51
	16.379	15.905	3.93	100.281	6,267.56	9.29	16.31	.43	26.03
	14.843	14.414	3.23	90.880	5,680.00	8.24	13.80	.36	22.40
	15.138	14.701	3.36	92.690	5,793.12	8.32	13.90	.37	22.59
Delta	20.854	16.700	4.34	108.416	6,776.00	18.86	15.32	− .39	33.79
	20.272	16.234	4.10	105.391	6,586.94	19.72	15.52	− .37	34.87
	21.250	17.017	4.50	110.474	6,904.63	19.17	15.80	− .42	34.55
Epsilon	22.522	19.847	6.13	112.592	7,037.00	9.85	22.78	1.34	33.97
	23.715	20.897	6.78	118.549	7,409.31	10.91	24.97	1.47	37.35
	23.583	20.787	6.69	117.641	7,352.56	10.24	25.05	1.46	36.75
	24.064	21.205	6.99	120.296	7,518.50	11.50	25.65	1.53	38.68
	24.492	21.582	7.24	122.435	7,652.19	11.95	26.60	1.58	40.13
	25.066	22.062	7.53	125.158	7,822.38	12.49	28.86	1.62	42.97
	24.944	21.981	7.51	124.698	7,723.63	12.46	28.70	1.75	42.91
Zeta	17.443	14.150	3.08	79.028	4,939.25	5.85	29.81	.72	36.38
	18.500	15.007	3.50	83.814	5,238.38	6.47	33.75	.85	41.07
	20.150	16.347	4.15	91.298	5,706.12	7.72	39.60	1.00	48.32
	20.250	16.428	4.19	91.750	5,734.37	7.85	41.29	1.01	50.15
	20.310	16.477	4.22	92.024	5,751.50	8.28	40.16	1.02	49.46
Iota	18.600	17.181	4.59	100.131	6,258.19	5.74	33.01	.60	39.35
	19.400	17.920	4.99	104.438	6,527.38	6.71	38.70	.70	46.11
	19.680	18.179	5.14	105.947	6,621.69	6.68	38.75	.72	46.15
	19.550	18.059	5.07	105.248	6,578.00	6.77	38.75	.71	46.23
	20.300	18.751	5.47	109.281	6,830.06	6.79	40.30	.77	47.86
	20.300	18.751	5.47	109.281	6,830.06	7.22	40.30	.77	48.29
Kappa	22.436	19.663	6.01	108.953	6,809.56	10.70	26.19	1.53	38.42
	23.634	20.713	6.67	114.771	7,173.19	11.22	28.07	1.69	40.98
	23.947	20.987	6.85	116.289	7,268.06	11.72	28.44	1.74	41.90
	23.925	20.968	6.84	116.184	7,261.50	11.72	28.44	1.74	41.90
	24.446	21.424	7.13	118.710	7,419.38	11.90	28.81	1.81	42.52
	24.505	21.476	7.17	118.998	7,437.37	12.23	28.82	1.82	42.87
	24.843	21.772	7.37	120.639	7,539.94	12.75	29.05	1.87	43.67
	25.200	22.085	7.55	122.373	7,648.31	12.94	29.35	1.89	44.18
Henry Flad	18.742	14.780	3.40	82.546	5,159.13	9.19	26.91	.83	36.93
	18.742	14.780	3.40	82.546	5,159.13	9.19	26.91	.83	36.93
	21.243	16.752	4.36	93.560	5,847.50	9.78	29.25	1.05	40.08
	21.549	16.993	4.49	94.906	5,931.63	10.78	30.32	1.09	42.19
	21.505	16.959	4.47	94.716	5,919.75	11.30	29.87	1.08	42.25
	21.694	17.108	4.55	95.548	5,971.75	11.30	30.24	1.10	42.64
	24.270	19.139	5.69	106.891	6,680.69	11.64	35.00	1.37	48.01
	22.208	17.513	4.77	97.810	6,113.13	11.14	31.95	1.15	44.24

Data and results of main pump tests, 1902—Continued.

Name of dredge.	Work done per second.	Efficiency of pump and engine.	Efficiency of pump.	Diameter of runner.	Peripheral velocity per second.	$\frac{\sqrt{2gh}}{V_p}$	Length of suction pipe.	Length of discharge pipe.	Remarks.
	Foot lbs.	*Per ct.*	*P. ct.*	*In.*	*Feet.*				
Gamma	108,175.08	66.1	71.4	69	42.7519	0.8879	57.0	596	500-foot pontoons.
	126,668.29	64.5	69.7	69	46.8648	.8145	......	......	
	147,849.46	65.6	70.8	69	48.1712	.8242	......	......	
	178,762.58	71	76.7	69	50.2787	.8138	......	......	
	127,232.00	65.7	70.6	69	46.0637	.8241	......	......	Suction head removed.
	180,866.58	67.4	72.8	69	46.3648	.8221	......	......	Do.
Delta	228,961.04	56.4	60.9	84	44.7154	1.0438	87.6	620.5	500-foot pontoons.
	229,686.59	56.6	61.1	84	44.7154	1.0591	......	......	
	238,554.96	55.3	59.7	84	45.4485	1.0372	......	......	
Epsilon	239,046.89	73.9	79.8	69	47.5691	.9828	68.5	590	Do.
	276,737.72	73.9	79.8	69	49.6766	.9866	......	......	
	270,206.58	71.4	77.1	69	49.9776	.9728	......	......	
	290,815.58	74.1	80	69	50.5798	.9862	......	......	
	307,082.38	72.8	78.6	69	51.4830	.9869	......	......	
	336,127.67	69.8	75.4	69	54.4937	.9647	......	......	
	331,420.96	69.4	74.9	69	54.4937	.9641	......	......	
Zeta	179,689.91	67.5	72.9	69	45.1605	1.0711	68.5	1,092	1,000-foot pontoons
	215,140.26	68.4	73.9	69	47.8700	1.0737	......	......	
	275,719.72	72.6	78.4	69	51.1819	1.0892	......	......	
	287,578.65	73.4	79.3	69	51.4830	1.1032	......	......	
	284,469.19	70.4	76	69	52.6873	1.0705	......	......	
Iota	246,259.77	67	72.4	75	49.4147	1.0181	56	682	500-foot pontoons.
	300,977.49	66.9	72.2	75	53.9963	1.0086	......	......	
	305,590.99	67.9	73.3	75	53.9963	1.0090	......	......	
	304,100.94	67.6	73	75	53.9963	1.0099	......	......	
	326,886.67	68.5	74	75	54.978	1.0092	......	......	
	329,823.59	69.1	74.6	75	54.978	1.0137	......	......	
Kappa	261,623.29	71.8	77.5	84	43.9826	1.1302	54	392	240-foot pontoons.
	293,957.32	71.7	77.4	84	45.0820	1.1388	......	......	
	304,531.71	69.7	75.3	84	46.1815	1.1241	......	......	
	304,256.85	69.3	74.8	84	46.1815	1.1241	......	......	
	315,472.03	70.1	75.7	84	46.5480	1.1235	......	......	
	318,840.05	68.6	74.1	84	47.2811	1.1106	......	......	
	329,269.18	67.5	72.9	84	48.3806	1.0954	......	......	
	337,902.83	66.3	71.6	84	48.7472	1.0936	......	......	
Henry Flad	190,526.67	64.4	69.5	84	42.1498	1.1563	54	642	480-foot pontoons.
	190,526.67	66.4	71.7	84	42.1498	1.1563	......	......	
	234,367.80	72.1	77.9	84	43.9826	1.1544	......	......	
	250,255.47	71.6	77.3	84	46.1815	1.1280	......	......	
	250,109.44	70.4	76	84	47.2811	1.1026	......	......	
	254,635.42	71.8	77.5	84	47.2811	1.1076	......	......	
	321,172.02	74.6	80.6	84	48.0141	1.1574	......	......	Pipes deflected at each joint to full throw.
	270,444.87	70.1	75.7	84	46,9146	1.1370	......	......	

NOTE.—Efficiency of pumps alone are based on assumed efficiency of the engines of 92 per cent.

Data and results of jet pump tests, 1902.

CENTRIFUGAL PUMPS.

Name of dredge.	Revolutions per minute.	Steam pressure.	Vacuum inches, mercury.	Total indicated horsepower.	Heads feet of water.				Inside diameter of pipe.	Area of pipe.
					Suction.	Delivery.	Velocity.	Total.		
		Lbs.							*Inches.*	*Sq. ft.*
Gamma	144	138	22.0	72.50	0.92	33.30	0.45	34.67	16⅞	1.553
	150	148	20.0	82.40	1.10	35.84	.48	37.42	16⅞	1.553
	194	146	20.5	140.04	1.40	46.00	.70	48.10	16⅞	1.553
Epsilon	212	140	......	53.61	.06	23.73	.38	24.17	17¾	1.718

Data and results of jet pump tests, 1902—Continued.

CENTRIFUGAL PUMPS—Continued.

Name of dredge.	Observed center velocity per second.	Mean velocity per second.	Discharge per second.	Discharge per second.	Work done per second.	Efficiency pump and engine.	Diameter of runner.	Peripheral velocity per second.	$\sqrt{2gh}$ V
	Feet.	*Feet.*	*Cu. ft.*	*Lbs.*	*Ft. lbs*	*Pr. ct.*	*Ins.*	*Feet.*	
Gamma	5.580	5.368	8,337	521.06	18,065.15	45.8	69	43.3541	1.0
	5.790	5.570	8,650	540.63	20,230.37	44.6	69	45.1605	1.0
	7.000	6.734	10,458	653.63	31,439.60	40.8	69	58.4076	.9
Epsilon	5.591	4.926	8,463	528.94	12,784.48	43.4	49	45.3259	.8

RECIPROCATING PUMPS.

Name of dredge.	Revolutions per minute.	Steam pressure.	Vacuum inches, mercury.	Total indicated horse power.	Delivery head.	Delivery head feet of water.	Distance from delivery gauge to water.	Total head feet of water.
		Lbs.			*Lbs.*			
Iota[a]	18	155	29	41.24	55	126.72	8	134.7
	20	155	29	54.23	67	154.37	8	162.3
Kappa	25½	161	18½	32.48	20	46.08	8	54.0
	26	158	18¾	35.53	23	52.99	8	60.9
	29	152	18¾	61.48	47	108.29	8	116.2
	40	139	18¼	102.10	62	142.85	8	150.8
	44	160	19	147.19	80	184.32	8	192.3
	45	150	19	156.50	85	195.84	8	203.8
	46	160	19	160.50	92	211.97	8	219 9
Flad	27	135	21½	42.64	40	92.16	8	100.1
	27	135	21½	48.66	40	92.16	8	100.1
	33	136	21½	80.92	70	161.28	8	169.2
	34	138	12	94.94	70	161.28	8	169.28
	38	135	21½	107.40	80	184.32	8	192.32
	38	138	12	115.46	80	184.32	8	192.32

Name of dredge.	Diameter of plunger.	Displacement of both plungers per stroke.	Water displaced per minute.	Water displaced per minute.	Work done per minute.	Work done per second.	Efficiency pump and engine.
	Inches.	*Sq. ft.*	*Cu. feet.*	*Pounds.*	*Ft. pounds.*	*Ft. lbs.*	*Per cent.*
Iota	16	5.510	123.975	7,748.44	1,043,869.84	17,397.83	76.7
	16	5.510	137.750	8,609.38	1,397,905.03	23,298.42	77.9
Kappa	16	5.510	175.631	10,976.94	593,632.92	9,893.88	55.4
	16	5.510	179.075	11,192.19	682,611.67	11,376.86	58.2
	16	5.510	199.737	12,483.56	1,451,713.19	24,195.22	71.5
	16	5.510	275.500	17,218.75	2,597,448.44	43,290.81	77.1
	16	5.510	303.050	18,940.62	3,642,660.04	60,711.00	75.0
	16	5.510	309.938	19,371.12	3,948,609.10	65,810.15	76.5
	16	5.510	316.825	19,801.56	4,355,749.15	72,595.97	82.2
Flad	16	5.510	185.976	11,623.50	1,164,209.76	19,403.50	82.7
	16	5.510	185.976	11,623.50	1,164,209.76	19,403.50	72.5
	16	5.510	227.304	14,206.50	2,404,876.32	40,081.27	90.0
	16	5.510	234.192	14,637.00	2,477,751.36	41,295.86	79.1
	16	5.510	261.744	16,359.00	3,146,162.88	52,436.05	88.8
	16	5.510	261.744	16,859.00	3,146,162.88	52,436.05	82.6

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[a] Work done computed from displacement of plungers; no allowance for slip made.

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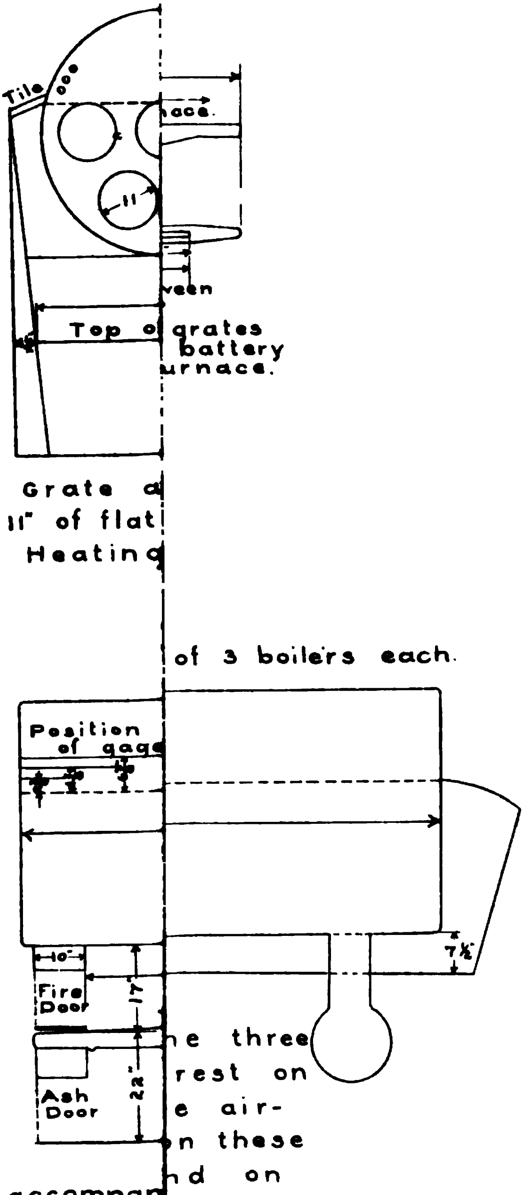

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F. B. Maltby U. S.

A. V. B. Candler. Del.

Eng 58 1

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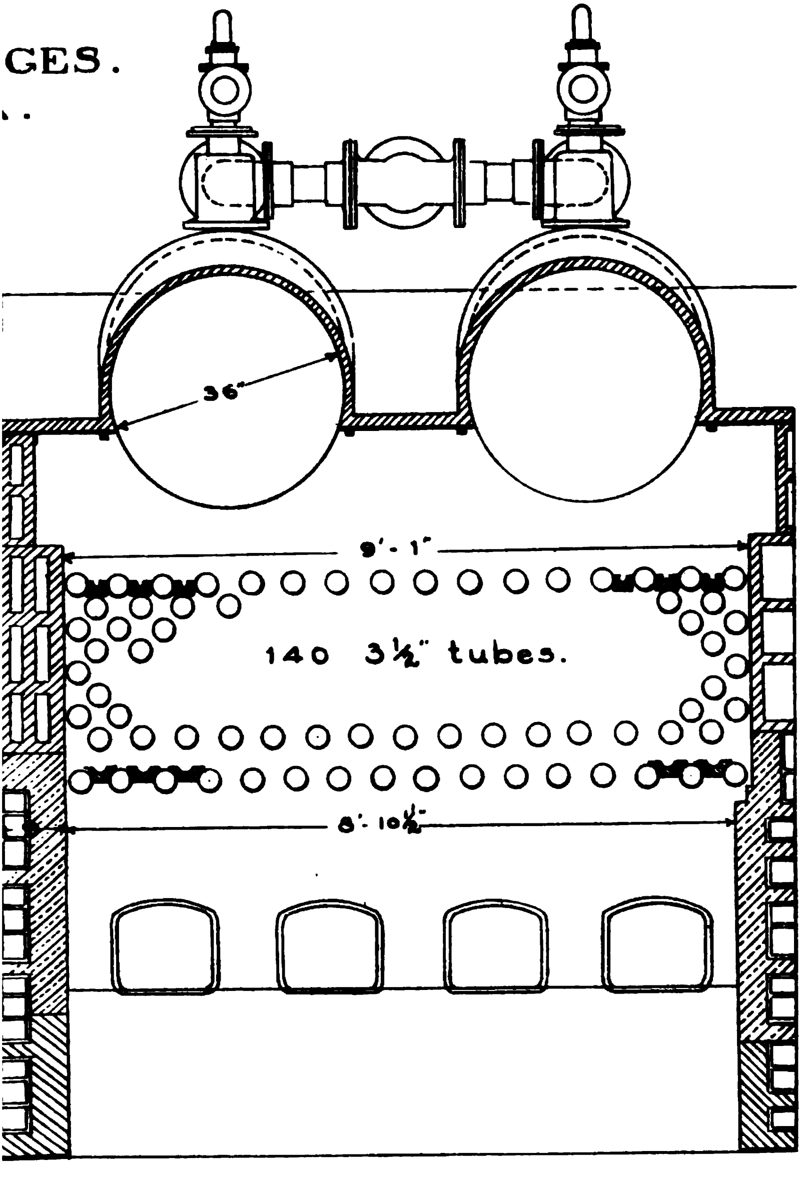

SECTION α-β

A.V.B. Candler, Del.

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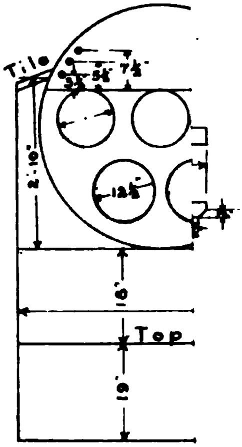

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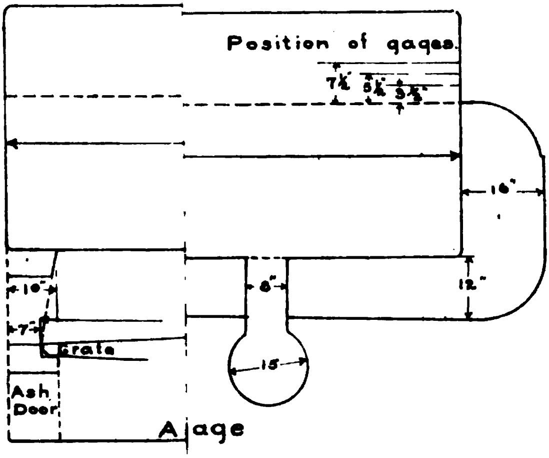

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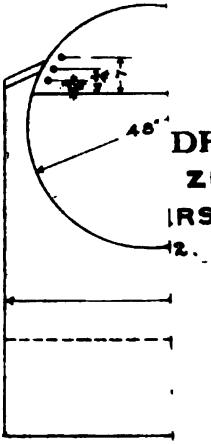

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Heating ft.
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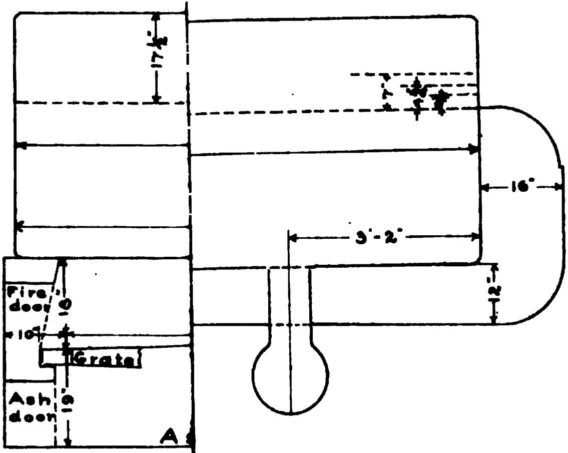

oiler battery except
To accompa of boiler The dimen-
of F. B. Maltby. ter end of boilers.
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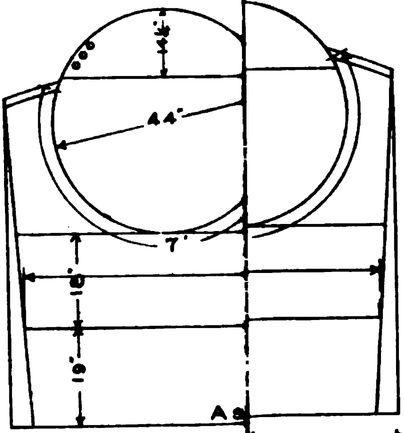
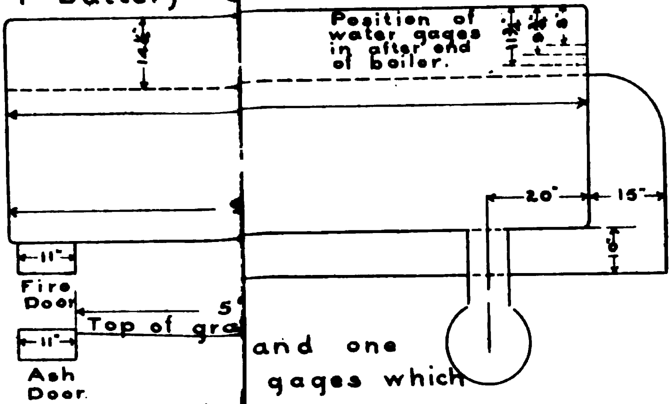
A.V.B. Candler, Del.

THE NORRIS PETERS CO PHOTO-LITHO., WASHINGTON D C



Heating surf t., except
center boiler al = 544.1 sq. ft.
Grate area 5 sq. ft.

2 Batteries
1 Battery



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gages which
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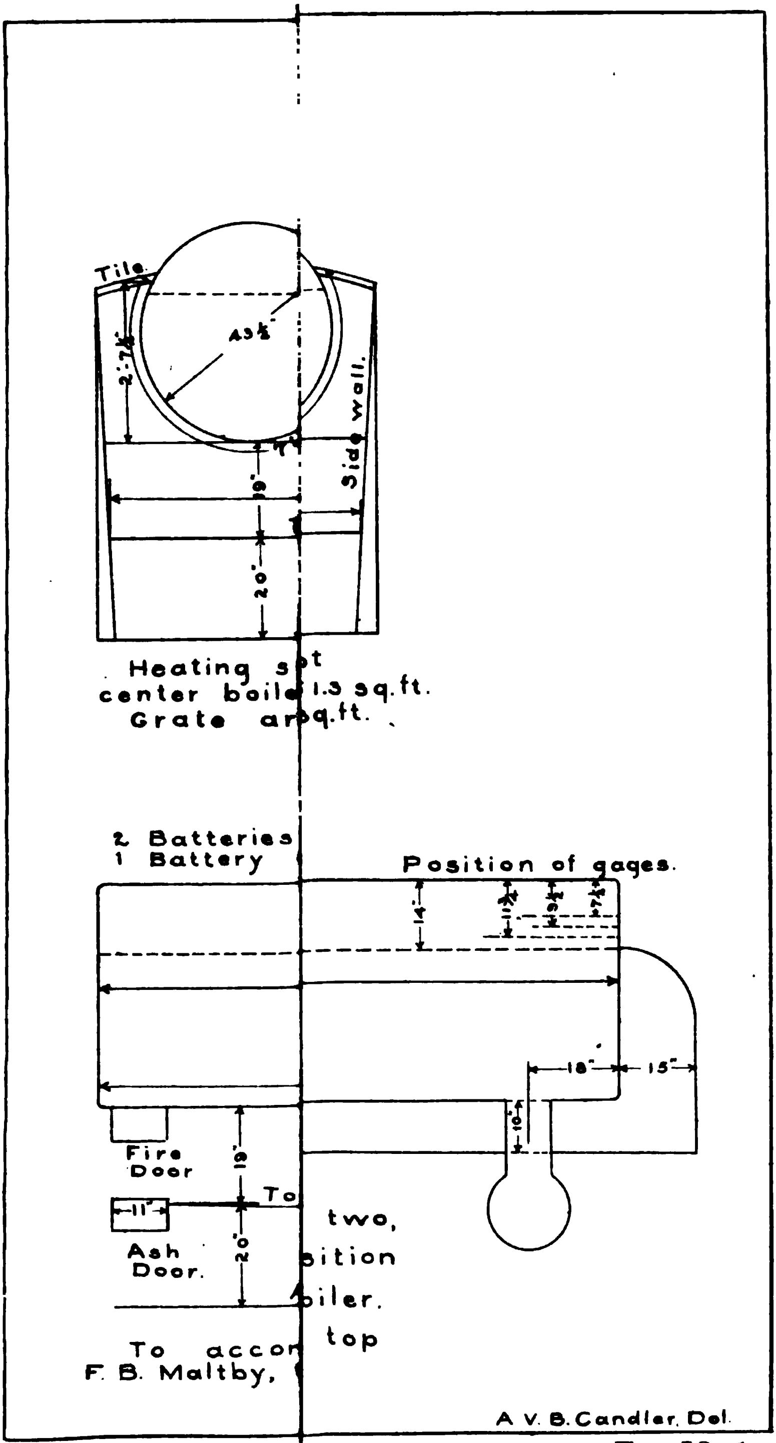
F. B. Maltby, U.

A.V.B. Candler, Del.

THE NORRIS PETERS CO., PHOTO-LITHO., WASHINGTON, D. C.


Tile.
43½"
2'-7½"
Side wall.
30"
20"
Heating s t
center boile 1.3 sq. ft.
Grate ar q. ft.
2 Batteries
1 Battery
Position of gages.
14"
11½"
9½"
7½"
18"
15"
10"
Fire Door
19"
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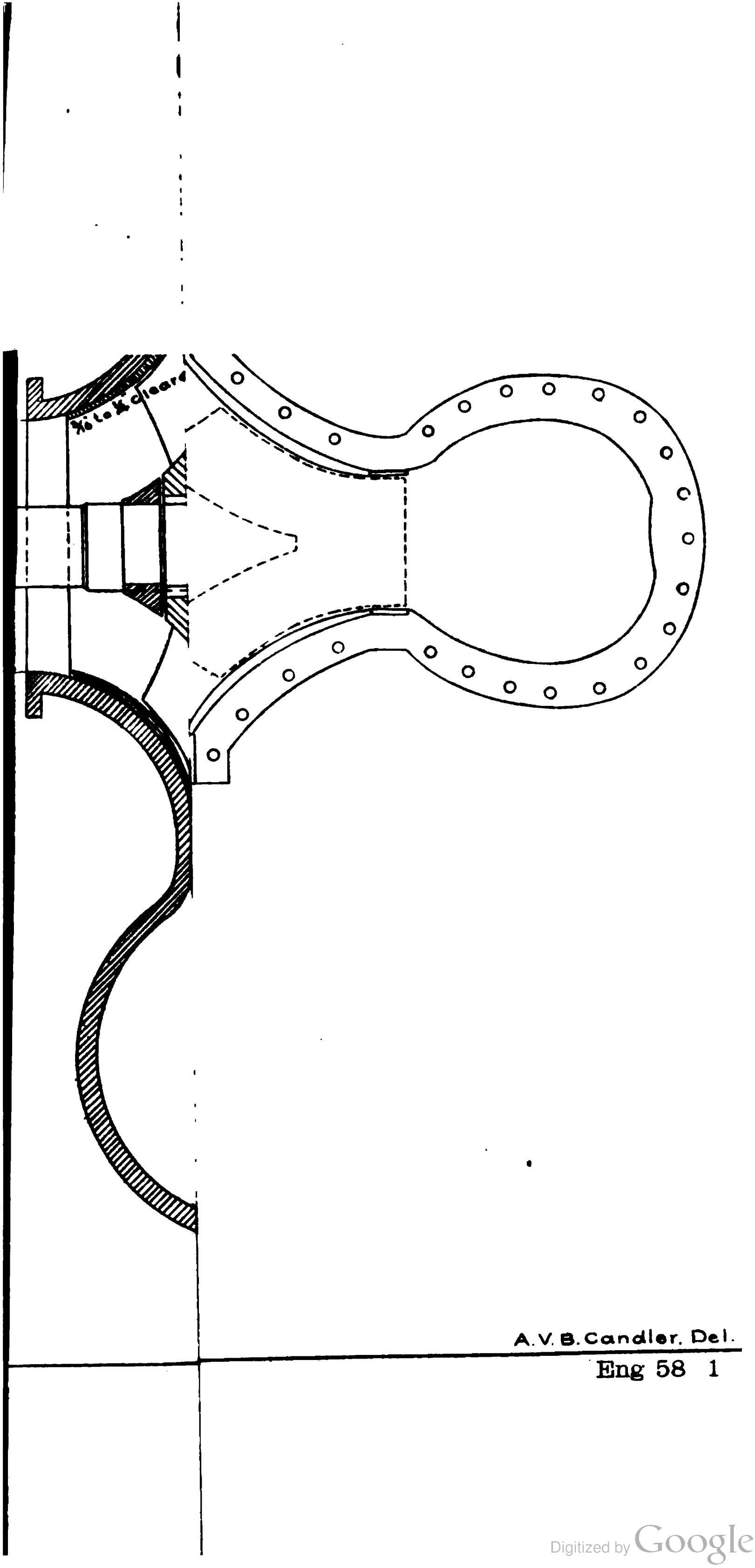
F. B. Maltby,
A. V. B. Candler, Del.



A. V. B. Candler, Del.

Eng 58 1

G DREDGES.

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IN PUMP.

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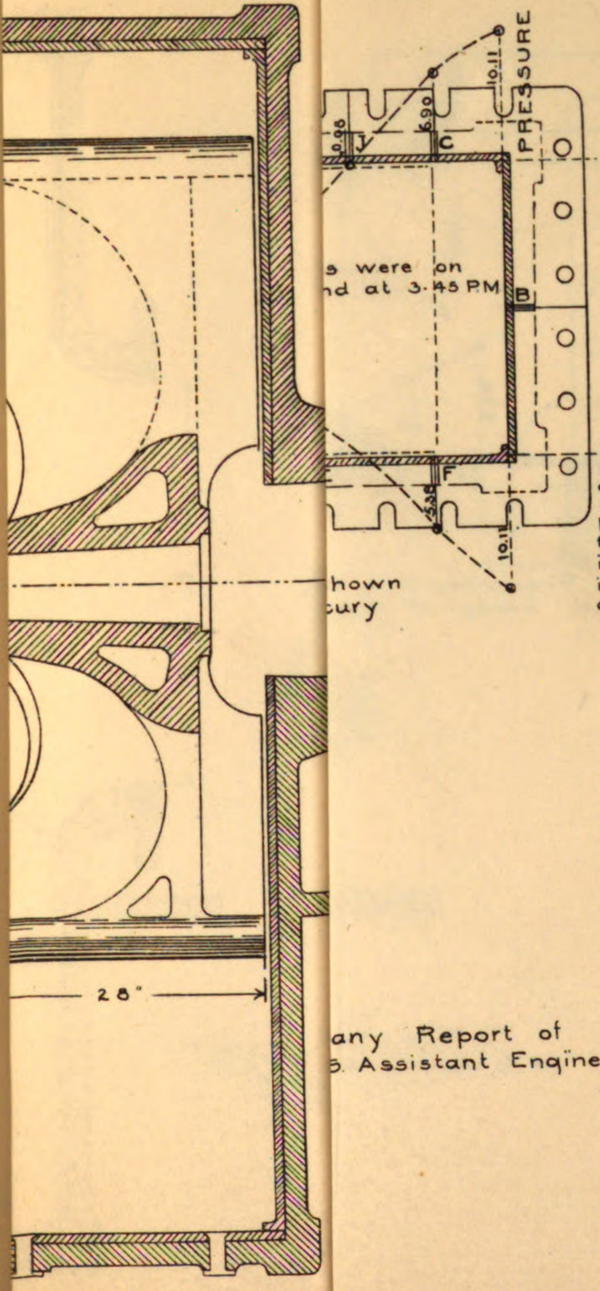
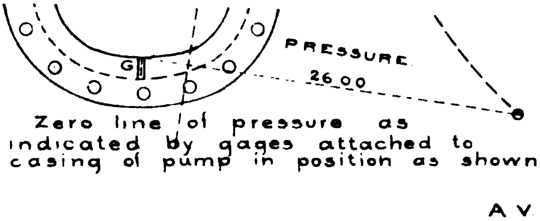


Zero line of suction and pressure as indicated by gages attached to cas ing of pump in positions as shown.

any Report of
S. Assistant Engineer.

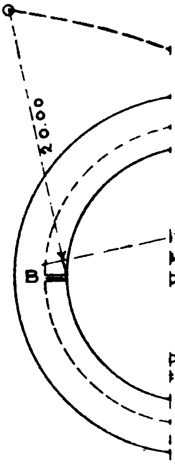
A. V. B Candler Del.

Eng 58


G
PRESSURE
26.00
Zero line of pressure as indicated by gages attached to casing of pump in position as shown

A. V. B. Candler. Del.

Eng 58



lf suction and
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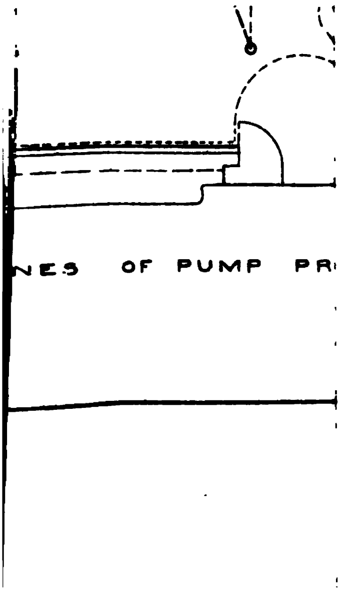
Eng 58 1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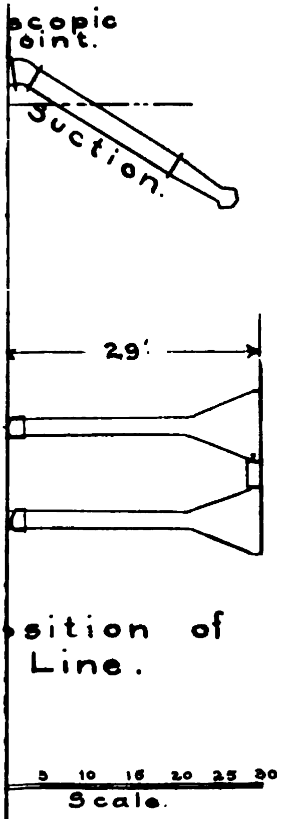

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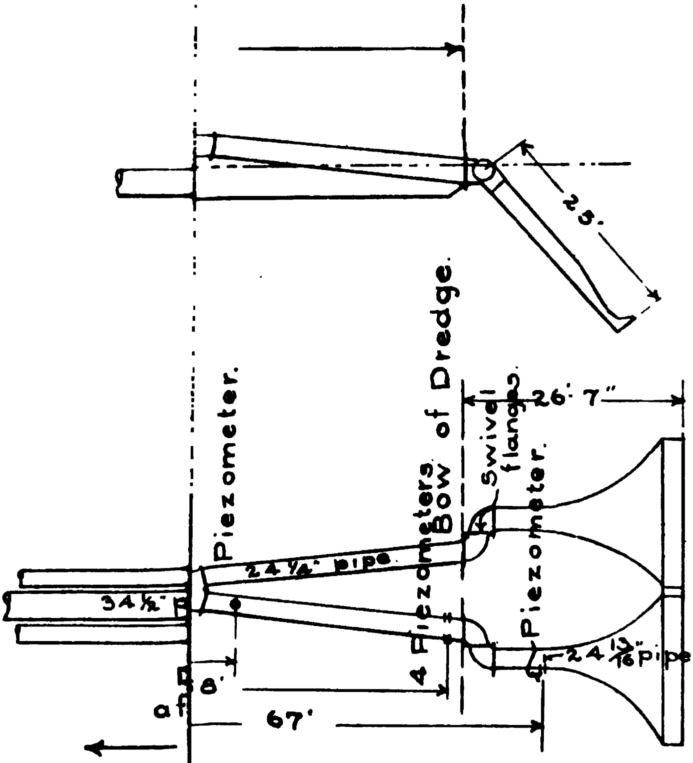

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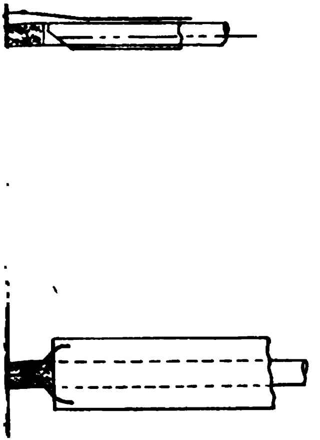

from ⟶
of pump.
Zeta.
to Piezometer.
to Pitot tube.
to. Piezometer.

Sh " "
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end of pipe.

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A. V. B. Candler, Del.

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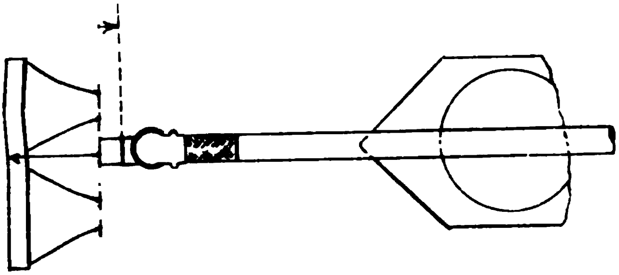

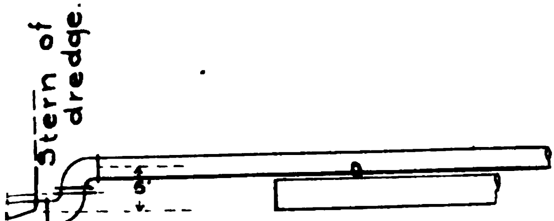

Distances from →
after flange of pump.
173' to Pitot tube.
223' " "
276½ to Piezometer.
380' " "
483½' " "
587' " "
637' " "
662' end of pipe.

A. V. B. Candler, Del.

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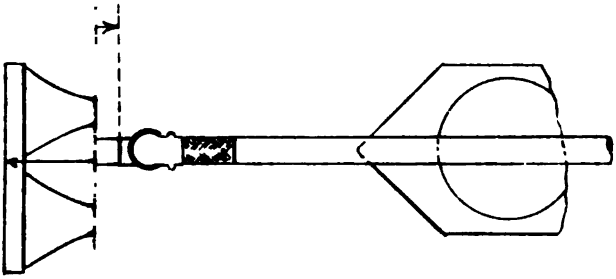
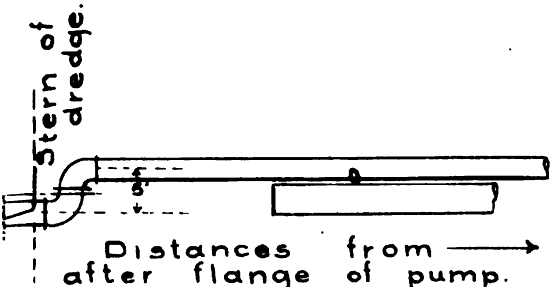
Eng 58 1

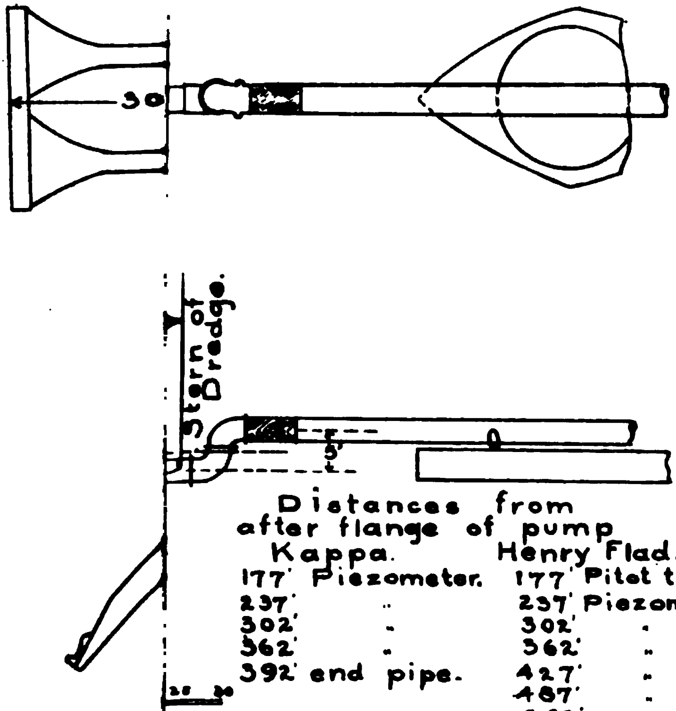




Distances from ⟶
after flange of pump.
173' to Pitot tube.
223' " "
276½ to Piezometer.
380' " "
483½ " "
587' " "
637' " "
662' end of pipe.

A. V. B. Candler, Del.

Eng 58 1



Distances from after flange of pump

Kappa.		Henry Flad.	
177'	Piezometer.	177'	Pitot tube.
237'	"	237'	Piezometer
302'	"	302'	"
362'	"	362'	"
392'	end pipe.	427'	"
		487'	"
		552'	"
		612'	"
		642'	End pipe.

To
F. B. M

A. V. B. Candler. Del.

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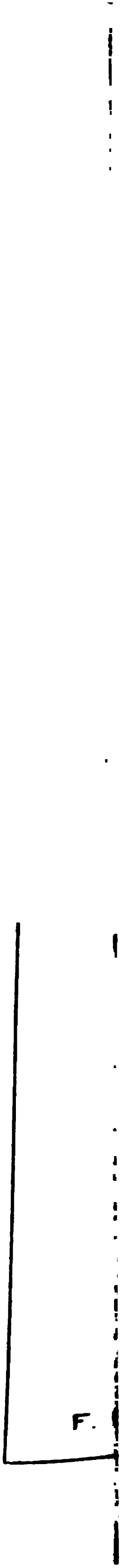

F.

LETTER OF ASST. ENGINEER F. B. MALTBY.

MEMPHIS, TENN., *June 17, 1903.*

CAPTAIN: As the Commission at its coming meeting may be interested in knowing the results of my recent tests with a 7-bladed runner, made on the *Zeta*, I have the honor to inclose herewith a table of results in the same form as that submitted with my report on testing.

As far as possible the same conditions were obtained in both tests. The same instruments for measuring were used and the same amount of discharge pipe was attached.

The mean efficiency with the 5-bladed runner at a speed of 170 to 175 revolutions is 72.1 per cent, while the mean efficiency with the 7-bladed runner at a speed of 168 to 175 revolutions is 73.1 per cent—no very great difference.

The diameter at the outside tip of the blades and at the inside shoulder was the same in each case. The amount of clearance, less than one-eighth inch, was also about the same.

The total amount of work done at the same speed is about 1 per cent less with the 7-bladed runner than with the 5, though with an efficiency of about 1 per cent higher.

Respectfully submitted.

F. B. MALTBY, *Assistant Engineer.*

Capt. WM. B. LADUE,
Corps of Engineers, U. S. A., Secretary Mississippi River Commission.

Data and results Dredge Zeta with 7-blade runner.

[May 22, 1903. 1,000 feet of discharge pipe. $\frac{V_m}{V_c}$ 0.8099 used.]

	Revolutions per minute.	Steam pressure.	Total indicated horsepower.	Suction pipes (2). Inside diameter.	Suction pipes (2). Area.	Suction pipes (2). Mean velocity per second.	Suction pipes (2). Velocity head of water.	Discharge pipe. Inside diameter.	Discharge pipe. Area.	Discharge pipe. Center velocity per second.
		Pounds.		*Inches.*	*Sq. feet.*	*Feet.*	*Feet.*	*Inches.*	*Sq. feet.*	*Feet.*
11.25 A...	180	135	....	24¼	6.414	....	....	32	5.585	....
11.38 A...	180	135	764.52	24¼	6.414	15.235	3.61	32	5.585	21.608
11.55 A...	180	135	770.15	24¼	6.414	15.648	3.80	32	5.585	22.182
1.15 P...	168	125	699.97	24¼	6.414	14.769	3.39	32	5.585	20.942
1.22 P...	170	133	665.83	24¼	6.414	14.854	3.43	32	5.585	21.063
1.39 P...	162	132	574.26	24¼	6.414	....	....	32	5.585	....
1.45 P...	161	132	569.33	24¼	6.414	14.017	3.05	32	5.585	19.875
1.57 P...	180	137	754.83	24¼	6.414	15.294	3.64	32	5.585	21.687
2.06 P...	175	128	703.53	24¼	6.414	15.093	3.54	32	5.585	21.402

	Discharge pipe. Mean velocity per second.	Discharge pipe. Velocity head of water.	Discharge per second.	Discharge per second.	Heads, feet of water. Suction.	Heads, feet of water. Delivery.	Heads, feet of water. Velocity.	Heads, feet of water. Total.	Work done per second.	Efficiency of pump and engine.	Diameter of runner.	Peripheral velocity per second.
	Feet.	*Feet.*	*Cub. ft.*	*Pounds.*					*Foot-lbs.*	*Pr. ct.*	*In.*	*Feet.*
11.25 A...	....	....	....	....	....	....	....	....	....	....	69	54.192
11.38 A...	17.496	4.76	97.715	6,107.19	6.90	40.73	1.15	48.78	297,908.1	70.85	69	54.192
11.55 A...	17.965	5.02	100.334	6,270.87	7.13	41.83	1.22	50.18	314,672.4	74.28	69	54.192
1.15 P...	16.961	4.47	94.727	5,920.44	6.13	37.35	1.08	44.56	263,814.2	75.01	69	50.579
1.22 P...	17.059	4.52	95.275	5,954.69	6.28	38.22	1.09	45.59	271,474.3	74.14	69	51.1819
1.39 P...	....	....	....	....	....	....	....	....	....	....	69	48.7728
1.45 P...	16.097	4.03	89.902	5,618.88	5.73	34.46	0.98	41.17	231,329.3	73.87	69	47.4115
1.57 P...	17.564	4.80	98.095	6,130.94	6.86	41.03	1.16	49.05	300,721.2	70.79	69	54.192
2.06 P...	17.333	4.67	96.805	6,050.31	6.56	39.17	1.13	46.86	283,517.5	73.27	69	52.566

APPENDIX 1 G.

REPORT OF PROF. W. B. GREGORY ON EFFICIENCY TESTS OF HYDRAULIC DREDGES.

TULANE UNIVERSITY OF LOUISIANA,
New Orleans, La., May 18, 1903.

CAPTAIN: In accordance with instructions conveyed in a letter, under date of February 24, 1903, from Capt. G. P. Howell, I hereby beg leave to submit the following report:

The general outline of dredge tests required by the committee on dredges and dredging, under resolution of Commission, is given in the report of Mr. F. B. Maltby, United States assistant engineer, superintendent of dredging operations. In the main they embody the suggestions conveyed by the writer in a letter to Maj. B. M. Harrod, under date of April 15, 1902, but contain many other instructions as to details of work.

The writer can not refrain from expressing his admiration for the thorough, capable, and painstaking way in which these instructions were carried out, the tests made and reported.

Boiler and engine tests were not taken up in the letter, as it was understood that the tests of main pumps were considered of the greatest importance, and as methods of conducting tests of boilers and engines were well known, standard rules for such tests having been recommended by the American Society of Mechanical Engineers.

Early in November, Capt. G. P. Howell, Corps of Engineers, U. S. Army, then secretary of the Mississippi River Commission, and Major Harrod called on the writer at Tulane University and the former engaged his services as consulting engineer in these tests, informing him that many tests had already been made and asking him to visit the dredging fleet at its winter quarters near Memphis to examine data, confer with Mr. Maltby as to the desirability of further tests, and offer such suggestions as circumstances might demand.

According to instructions, writer left New Orleans on the evening of November 19, 1902, arriving at Memphis the next day. He returned to New Orleans November 26.

During this first visit much data were examined and ways were suggested to obtain constants for the various Pitot tubes and to establish what was believed to be a fact, namely, that tubes Nos. 8 and 9 had a constant equal to unity in the equation $v=c\sqrt{2gh}$.

Again, on December 6, writer left New Orleans for Memphis, remaining at the fleet until December 23, when he returned home.

During the second visit data obtained since first visit were examined, and, as they were not conclusive, further tests were conducted, in which the writer participated. These tests established the fact that the formula $v=\sqrt{2gh}$ was correct for tubes Nos. 8 and 9, and included tests of engines of dredges *Epsilon*, *Iota*, and *Kappa*. Results of tests will be discussed in the order given in the general description of tests by Mr. Maltby.

BOILERS.

These tests were undertaken to give data for ordinary, everyday running. This they do very well, but they do not contain all the information necessary for a satisfactory analysis of results, and so only the most general conclusions can be drawn.

Two kinds of boilers were tested, viz, the water-tube and a kind of horizontal fire-tubular boiler, which is known as the Mississippi River boiler. One peculiarity of the furnace in the latter type of boiler is the small distance between top of grate bars and bottom of boiler shells, which is much less than in stationary boiler practice. In the furnace of the *Gamma*, for instance, the distance from grate to bottom of boilers is 17 inches at the front, while at rear end of grate it is only 15 inches. In stationary boilers 20 to 24 inches, or even more, is considered good practice, the idea being to allow space enough for perfect combustion before the hot gases come in contact with the comparatively cool surfaces of boilers.

The flame bed is also high behind the bridge wall. It appears that the gases in passing backward along the surfaces of those boilers are compelled to pass between and around the sides, which may account for the high efficiency of heating surfaces.

According to Kent, for a fuel completely burned in the furnace and a given steam pressure, the evaporation per pound of combustible depends on several quantities, viz: The heating value of the coal; the difference of temperature between boiler and air; the weight of flue gas per pound of combustible, which in turn depends on the force of draft and the condition of the fire; rate of driving and radiation. It also depends on the manner in which gases pass through furnace, dead spaces, eddies, etc.

The amount of draft is one of the most important factors. The draft in all these tests was "good," but it was not measured. No analysis was made of the flue gases, so we do not know how much air, above the quantity needed to supply oxygen, was furnished, or if any.

The moisture in the coal was not determined; as coal was kept in open barges the amount of moisture contained is difficult to estimate.

Attention is called to these facts merely to show that a scientific analysis of results is impossible. However, one point is obvious: it is that in these tests the capacity of the Mississippi River boiler is far superior to that of the water-tube boiler on the basis of square feet of heating surface.

For each pound of water evaporated per hour from and at 212° the average heating surface of all tested was 0.148 square foot for the former and 0.28 for the latter. While the average heating surface per horsepower was 5.11 square feet for the fire-tube boilers, it was 9.69 square feet for the water-tube.

The average equivalent evaporation per pound of combustible from and at 212° for the former was 9.1, while for the latter it was 9.32. For the boilers of the *Gamma* it was 10.64.

Great capacity is obtained, especially in the Mississippi River boilers, at a sacrifice of economy, although comparison shows the economy of the fire tube to be nearly equal to, in the average case, and in one case to greatly exceed, that of the water-tube type.

Mr. Maltby has pointed out the gain to be had from the use of a feed-water heater; the point is well taken.

MAIN ENGINES.

In order to study the results of the tests of the engines of the *Epsilon* and *Kappa* more carefully, a set of cards from each test has been selected and combined. Separate cards from each test have been combined for the starboard and port engines, using mean volumes of high and low pressures, as shown by average of crank and head ends in each case. The particular set of cards to combine were chosen because of their close agreement in mean effective pressures and in number of revolutions per minute with the average of all cards taken during the test.

The clearances of the engines of the *Kappa* were obtained from the cards, assuming hyperbolic expansion. The values obtained were mean clearance, high-pressure cylinder, 11.6 per cent; low-pressure cylinder, 5.6 per cent.

It was impossible to use this method on the cards from the engine of the *Epsilon* as they were taken at an average of 172.7 revolutions per minute and showed many irregularities, which were absent from those of the *Kappa*, which were taken at an average of 129.8 revolutions per minute. The mean clearance of the high-pressure cylinders of the *Epsilon* were assumed to be 11 per cent and the low pressure 6 per cent.

From known clearances of other engines of the same make and approximately of the same size, it is believed that these values are not far from the truth.

A glance at these combined cards is sufficient to convince one of the necessary loss in the noncondensing engine. There is a large "drop" in pressure at high pressure release and a low ratio of expansion.

The indicator springs were calibrated by the writer and found to be within the limit of probable error of observation.

The consumption of steam per horsepower hour, 26.06 for the noncondensing and 21.42 for the condensing engine, showed a balance of 4.64 pounds in favor of the condensing engine. It is necessary to add about 21.7 per cent to the water rate of the condensing engine to obtain that of the noncondensing.

The results correspond to carefully conducted tests made elsewhere, and are also such as theory would lead us to expect when all the various losses are considered.

As the greater part of all the steam generated in the boilers is used in the main engines, the coal bill can evidently be greatly reduced by using feed-water heaters and condensing engines.

MAIN PUMPS.

The various problems presented by the main pumps are of the greatest interest.

METHODS OF MEASURING DISCHARGE VELOCITIES.

The method used to measure the velocity in discharge pipe is believed to be practically the only method that could be successfully employed in this case. Other methods were suggested. The Venturi meter is known to be an accurate instrument, capable of giving results within 3 per cent of the truth, and possibly closer average results; but unless an abnormally large meter could be used, the loss of head at the throat, for velocities such as were to be measured, would be excessive, and the pressure head necessary to overcome this loss would give abnormal conditions for the pumps. Its weight would necessarily be great, and after placing it on a suitable barge it would have to be attached successively to pipes of different diameters and at varying heights from the surface of the water, as the several pumps were tested.

A weir might have been constructed, but the uncertain stages of the river made it doubtful how long it would have been of service.

A measuring barge might have been used in which water could be pumped for a known length of time.

The Pitot-tube method is believed to be as accurate as any of the ways suggested above, and has the great advantage of ease of application without materially changing the normal condition of discharge.

The Pitot tubes Nos. 8 and 9, when calibrated in running water by means of floats, showed an average constant of unity in the formula $v=c\sqrt{2gh}$ within one-third of 1 per cent.

These two tubes under very different static pressures showed average velocity readings which differed by only one-tenth of 1 per cent. The difference in static pressure amounted to about 17.7 feet of water. One tube was used where the static pressure was nearly five times as great as that at the section where the other tube was used; yet, as already stated, results agreed within one-tenth of 1 per cent.

As these results were obtained from 170 observations the agreement is not accidental. This experiment shows that the results are not affected by a difference of static pressure. Other data are given in the report of Mr. Maltby illustrating this point still further.

It was also shown that the pressure obtained by means of a piezometer at the outside of a straight pipe in which water is flowing is precisely the pressure of the entire cross section of the pipe, corrected, of course, by height of point considered; and that it agreed exactly with the static side of a properly constructed Pitot tube at that section. That in a straight pipe a Pitot tube can be used with impact opening only, and static pressure obtained by means of a carefully inserted piezometer at outside of pipe, is thus clearly shown.

From the above facts it is evident that the behavior of a correctly designed Pitot tube, when used in an open canal or in a discharge pipe under pressure, is practically the same. There was no suction action on the static side of the tube, and the impact reading was not affected by great difference of static pressure. It therefore follows that the constant of tubes Nos. 8 and 9 must be unity.

In making a traverse of a pipe considerable time was required; as much as an hour or even more was sometimes used, consequently, irregularities appear, due to the practical impossibility of keeping conditions of speed of engines and pumps absolutely constant, as well as to other causes.

The pressure throughout the section of a straight pipe in which water is flowing, corrected for difference of height of the points examined, was shown to be a constant quantity, as already stated.

A great mass of data on this point was collected. The velocity parallel to axis of pipe was found to be very much greater at the center than at the surface. A platting of many results of the traverses in the discharge pipe of the *Epsilon* shows the mean-velocity curve to be an ellipse, and that the velocity of the entire cross section can be represented by an ellipsoid of revolution. This agrees with results found, at much lower velocities, by Messrs. Williams, Hubbell, and Fenkell in their Detroit experiments.

As pointed out by Mr. Maltby, there was some variation in the traverses in the general discharge pipes due to local irregularities, and so the ratio of center to mean velocity was not a constant quantity.

In some cases the center velocity was over 25 feet per second, while that near the pipe was as low as 18 feet per second, parallel to the axis of the pipe.

Bernouilli's theorem states that the sum of static and velocity heads in any two sections of the same pipe are equal when corrected for the loss of head due to friction between the two sections.

If it is understood to mean that the sum of the velocity and static heads at all points in a given cross section are equal, it can only be true when the absolute velocity of the various particles of water is considered and not the velocity parallel to axis of pipe. The particles of water in the outer part of the moving mass encounter friction with the walls of the pipe and are retarded; complicated cross currents are undoubtedly set up. Particles in the outer part of the moving stream exert an influence on their neighbors, and this extends to the center of the pipe, where the disturbances are least. The velocities of particles relative to each other are thus greatest at the outside and least at the center. If it were possible to measure these absolute velocities and so to find the velocity head corresponding to them, it is believed that Bernouilli's theorem would be true for all points in a cross section.

METHOD OF COMPUTING TOTAL WORK OF PUMPS.

The tests of 1897, made while pumping sand, have been reworked by Mr. Maltby and form a part of his report. These tests as originally published are incorrect, as they credit pumps with the sum of head shown by discharge pressure minus the negative head shown by suction pressure, which includes the velocity head in suction pipe and the computed velocity head in discharge pipe. Now, if suction and discharge pipes were of the same cross section, the method used in computing tests as reported gives twice the velocity head, and is therefore in error by the amount of the velocity head. As the suction and discharge pipes are usually unequal in sectional area a correction must be made, due to the difference of velocity head at these two sections. This point will be taken up again later.

Another point is misleading in the report of tests of 1897, although the actual error involved is very small. The various heads are always stated in feet of water. As a matter of fact a mixture of sand and water was pumped, and the heads ought to be measured in feet of liquid pumped—that is, the mixture.

In some cases instead of 62.5 pounds per cubic foot the mixture weighed between 70 and 75 pounds per cubic foot.

In any case the work done by a pump is equal to $Q\times W\times H$, where—

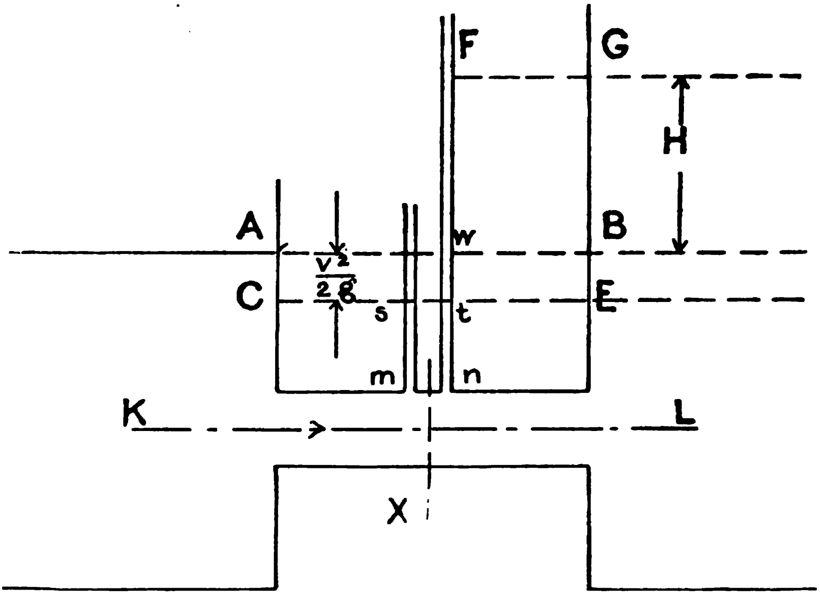
Q=volume pumped per unit of time.
W=weight per unit volume of liquid pumped.
H=total head$=h_d-h_s+h'+h''$.
h_d=discharge head, obtained by observing the pressure p_d, at some point in the discharge pipe, then $h=\frac{p_d}{W}$.
$h_s=\frac{p_s}{W}$=suction head, obtained at some point in suction pipe by observing the pressure p_s. It includes the velocity head, as will be shown.
h'=difference between velocity heads in discharge and suction pipes.
h''=difference in level of the two points where discharge and suction pressures are measured.

$$\text{Total work}=Q\times W\times(h_d-h_s+h'+h'')=Q\times W\times\left(\frac{p_d}{W}-\frac{p_s}{W}+h'+h''\right).$$

It will be seen that nearly all the total head is included in the first two terms of the quantity within the parentheses and that the error arising from computing results when pumping sand due to using the weight of a unit volume of water instead of the weight of unit volume of the mixture only affects the last two terms. In the case of h' it is small enough to neglect and probably so in the case of h''.

It is to be noted that h_s is always negative in these tests, but both h' and h'' may be positive, negative, or zero, depending on conditions in individual cases. Very little error will therefore be made by using W as the weight per unit volume of water instead of the weight of mixture pumped, and the method of computing results is greatly simplified.

It will now be shown that the suction pressure includes the velocity head in suction pipe where pressure is measured.



Referring to figure, let two tanks *K* and *L* be connected by a pipe of uniform cross section in which water flows with a constant velocity *v* when the level of the water in the tank *K* is at *A*. Suppose a suitable supply provided for tank *K* or that the water level is always kept at *A*; also an outflow provided for tank *L*, so that water may be discharged into *L* and a desired height always maintained.

Now, neglecting losses due to friction in pipe at entrance, etc., the "hydraulic gradient" would take the position of line CE, and this would be the level of the water in the tank *L* to maintain continuous flow at a velocity of *v* feet per second. $AC=BE=\frac{v^2}{2g}$. Let two piezometers be placed in pipe at *m* and *n;* the level in these piezometers would be *s*, *t*.

Suppose at section *X* we cut pipe and introduce a pump, which will always maintain the uniform velocity *v* in the pipe and also deliver the water into tank *L* at a level *AB*. The level of water in discharge tank will then just equal that in suction tank, and the work of the pump will clearly be to produce the velocity head.

At the left of section *X* the conditions are unchanged from those of the first case taken, for the constant velocity *v* is maintained.

The height of the water in piezometer *m* will therefore be at *s*. On the right of section *X* the level of water in tank *L* is raised to *B*, and therefore the water in piezometer *n* will stand at *w*.

The difference between the readings of the two piezometers will thus be seen to include the velocity head; in fact, in this case would be just equal to the velocity head.

Again, if water is pumped into tank *L* and the level in tank is raised to *G*, while the same velocity *v* is maintained in suction and discharge pipes, the level of water in piezometer *n* would be at *F*, while in the piezometer *m* it would still stand at *s*; the difference between these two readings would plainly be $EG=\frac{v^2}{2g}+H$ and is seen to include the velocity head.

The simplest possible case has been taken to prove this point; the proof still holds, however, if we consider all losses in the pipe.

It will be seen that if section at *m* differs in size from that at *n*, the hydraulic gradient will not be a straight line; but in any case the velocity head which is included is that at *m*, i. e., the velocity head corresponding to the velocity in suction pipe. The velocity head in discharge pipe will not be shown by piezometer, but may be computed. If it is more than that in suction pipe the difference must be added to suction and discharge heads; that is, h' is positive; if less, h' is negative; in the equation $H=h_d-h_s+h'+h''$.

The correction for difference of level h'', at which discharge and suction pressures are obtained, has been already referred to.

Then, knowing discharge head, suction head, the difference (if any) in velocity heads in discharge and suction pipes, the correction due to difference of level, and the proper sign for each and all of these quantities, we are able to compute the total head H.

From the mean velocity in discharge pipe the quantity pumped is known, and we thus have all quantities necessary to determine the total energy given by pump to water as accounted for between a point in suction pipe and another point in discharge pipe. One possible error arises from the assumption of the mechanical efficiency of all the engines as 92 per cent.

The cards taken on the *Gamma* showed the friction to be about 6 per cent, while on the *Iota* it was about 12 per cent. Any engineer who has tried to obtain the friction cards from an engine realizes how unsatisfactory the results usually are. In this case they were so much so that it was decided to use a constant quantity for all. It is not improbable that a small error was introduced here, which, if it could be known, would slightly change results.

EFFICIENCIES OF PUMPS.

When an attempt is made to find the reason of high efficiency in one case or low efficiency in the other of the main pumps the greatest difficulties are encountered.

Hydraulic problems are very complex and must be attacked largely from the experimental side. An example will illustrate this. Only three years ago it was maintained by some engineers of the highest standing in America, in discussing the Pitot tube, that velocity head and static head were not mutually convertible. The admirable researches of Mr. W. M. White settled this point.

In a centrifugal pump with many blades, and where the path of the water is therefore well circumscribed, it would be possible to take a series of tests, and, knowing the quantity of water pumped, angular velocity of impeller, shape of blades and of pump casing, to analyze those results with more or less accuracy and locate losses with some degree of certainty. When, however, the number of blades on impellers is only four or five the mean path of the water through them becomes very uncertain, and thus the problem of locating losses proportionately harder. The problem depends on many conditions, even in pumps of the same form and size, the head pumped against, the quantity pumped, and the velocity of rotation of impellers, all of which are interdependent and may vary widely.

Here, then, is a problem in which theory can only suggest probabilities and experiment must decide.

In each of the main pumps the writer has attempted to follow the path of the water as best he could from the suction pipe into and along runner at the periphery and through vortex chambers to discharge pipe. The results are not satisfactory for the reasons already stated; however, they suggested a few points which will be mentioned.

Radial flow to impeller was assumed; its mean value was obtained from the dimensions of pump and knowing the quantity of water pumped. This velocity, together with the known velocity of rotation at inner ends of runners, should determine the angle at which the water enters the blades and show the amount of shock, if any, provided that the assumption of radial flow is correct.

As a matter of fact we know that this assumption is not absolutely correct, as shown by the wear at the intake of the pump casing.

The amount of this whirl that is set up before water enters blades of impellers was not measured and is not known. It is probably less on those pumps provided with plates in suction elbows to prevent such whirl. However, this assumption of radial flow offers a working hypothesis.

On this basis the *Delta* shows by far the greatest loss in shock at intake, while the *Gamma* shows the least, the *Epsilon* being next to the *Gamma*. The runner of the *Gamma* has only 4 blades, which makes the results possibly less reliable than in the *Epsilon* and *Delta* with 5 blades.

Any sudden change of velocities in the water along its path through the pump is accompanied by losses due to shock and to eddies. The velocities throughout the pump of the *Epsilon* are far more uniform than for any of the other cases. Among the other pumps, possibly the *Gamma* has more uniform velocities throughout the pump than any other. However, there are sudden changes in all.

It is known to be a fact that where a small number of blades are used on impellers cobblestones have been retained for some time behind runners instead of being thrown out radially. This, of course, could only be due to eddies which would be largely overcome by increasing the number of blades, but the increase of surface would cause greater surface-friction losses.

In another class of hydraulic machines, viz, turbines, it has been found desirable to use a great many blades. The question of the proper number of blades for a centrifugal pump can best be settled by experiment. The writer does not know of any such experiments having been made.

The efficiencies obtained in every case, except that of the *Delta*, are very satisfactory and fairly uniform. Undoubtedly they are not absolute efficiencies, but it is believed that they are as close to the truth as it is possible to arrive by careful experimentation.

It is a noteworthy fact that the *Gamma* gave almost identical results for the efficiency tests of 1897, made while pumping sand, and the tests of 1902, made while pumping water, when efficiencies are corrected in the former.

The pump was the same in both tests, having been merely kept in repair since the first tests. However, the "total head" for the two sets of tests was quite different.

The *Epsilon* and *Zeta* showed much higher efficiencies in 1897, when they had impellers with 7 blades and the angles of intake of these blades different from that on the 5-blade impellers now in use. The total head and the revolutions per minute all vary, and it is therefore impossible to draw any definite conclusions from a comparison of the results of these two sets of tests. However, the great difference between the revolutions of the *Delta* may account for the low efficiency of the pump in the test of 1902, at least partially. In both cases the *Delta* shows the lowest efficiency.

Highest average efficiency was attained with a pump having a vortex chamber circular in cross section, while the lowest was attained by a pump having a rectangular cross section for its vortex chamber. The highest individual efficiency was attained on the *Flad*. Both the *Kappa* and the *Flad*, with their square casings, showed good average results.

The writer has failed to discover any obstacle worth considering to the use of a double suction. Certainly from the mechanical standpoint the perfect balance resulting makes it highly desirable.

The single-suction pump showed the lowest efficiency. This, however, does not prove anything, as proportions of casings, shapes of impellers, total head, etc., varied widely in the different pumps.

JET PUMPS.

A comparison between the compound-condensing, direct-acting steam pumps and the centrifugal pumps driven by means of compound-condensing engines should include the relative consumption of steam in the two types of engines. The former, in the experience of the writer, requires about 33 pounds of steam per horsepower hour, while the latter requires between 22 and 25 pounds.

The probable gain in steam consumption by using the high-speed compound-condensing engine, in average cases, will not be far from 25 or 30 per cent.

The greater steam economy of the engine of the centrifugal pump will thus partially offset the superior efficiency of the reciprocating pump. The slip and leakage in the reciprocating pumps may also be quite an appreciable quantity.

LOSS OF HEAD IN DISCHARGE PIPE.

The loss of head due to the double elbow at the stern of dredges *Kappa*, *Iota*, and *Flad* varies somewhat. This point has been discussed by Mr. Maltby.

The discharge pipes have countersunk rivets and are polished smooth and bright by the sand. The only disturbing influences in the flow of the water with a straight discharge pipe are due to the lapping of the various sections where they are riveted and to the flexible rubber joints connecting the different lengths of pipe.

These pipes are made up of sections, each being inserted into the succeeding section, thus making the mean area of pipe at the center of the section, where all these piezometer pressures were measured.

In case discharge pipes are not straight, there is loss due to the curvature of these flexible joints. The drop along the discharge pipe of the *Flad* shows the latter loss to be small even in the extreme case.

Mr. Maltby has given the data in the case of the four air cocks placed on the "quarters" of a section of pipe. It is to be remembered that these air cocks were purposely placed to show the greatest possible error, and that it is extremely improbable that any such variation as they showed ever occurred in the data obtained in the tests.

As there is very little data on losses in pipes of this size, and at high velocities obtained, the results are of peculiar interest and value.

Using the formula $H_f=\frac{4fL}{D}\frac{v^2}{2g}$ or $f=\frac{DH_f}{4LHv}$, we may compute from the data given the value of the coefficient of friction f, for the pipes, including the flexible rubber connections.

The values of f as again given in the above formula, and obtained in most cases from mean values, are shown in the table below:

Name of dredge.	Diameter of discharge pipe.	f.
	Inches.	
Gamma	34	0.00445
Delta	34¼	.00547
Zeta	32	.00569
Iota	32 11/16	.00455
Kappa	31⅞	.00412
Flad	32	.00556
Average		.00508

The fact that zero pressure was found in the side of the discharge pipes of the *Iota*, *Kappa*, and *Flad* is accounted for by the fact that the water was flowing at a constant velocity in an open pipe, the only force retarding it being the skin friction and viscosity of water. The pressure will be zero when we go back from the discharge end of pipe to a section at which the force necessary to overcome this friction was just balanced by the head due to the open end of the pipe. The piezometer was at the center of the pipe, so the pressure ought to be neutral at such a distance as will make $H_f=\frac{D}{2}$. Results show this distance to be approximately 30 feet.

AMOUNT OF SAND IN MIXTURE PUMPED.

It is interesting to find the sand so thoroughly mixed with the water; the results indicate that there was slightly more on the lower side than on the top side of pipe, but that the mixture was fairly uniform.

If the pipe were inserted in discharge pipe at such a point that the static pressure were great enough to give the water in sampling pipe the same velocity as the water surrounding this pipe has on its way to the end of discharge pipe—in other words, at such a point that it is equally easy for water to escape from sampling and discharge pipes—there could be no doubt about obtaining an average sample.

Respectfully submitted.

W. B. Gregory, *Consulting Engineer.*

Capt. Wm. B. Ladue,
Corps of Engineers, U. S. Army,
Secretary Mississippi River Commission.

Appendix 1 H.

REPORT OF ASST. ENGINEER A. T. MORROW ON DEEP WATERWAY SURVEY, MOUTH OF ILLINOIS RIVER TO ST. LOUIS, MO., SEASON OF 1902.

St. Louis, Mo., *May 6, 1903.*

Captain: I have the honor to submit the following report on the work done, under my charge, by the party known as the waterways survey party.

Work was begun at the mouth of the Illinois River on August 28, 1902, and completed to the head of Arsenal Island, 4 miles below the Eads Bridge, on September 30. The distance covered by the survey is 43.6 miles. The party was quartered on the steamer *Patrol* and the quarterboat *Illinois*, and consisted of the following subparties: Two topographical parties, two hydrographical parties, and one level party, the entire party of surveyors and men numbering about fifty. The survey was prosecuted in accordance with instructions from Capt. G. P. Howell.

The work consisted of a topographical survey of the banks, bars, and as much of the islands as had undergone material change since the general survey of the Mississippi River Commission, lines of soundings crossing the river at intervals of 500 feet, and a line of levels on one bank of the river (and mostly on both banks) determining elevations of the water surface and furnishing elevations for the topography. The survey was based on the permanent marks of the Mississippi River Commission. The positions and elevations of these marks were assumed to be correct, and the lines of topography and levels were adjusted thereto.

Unfortunately, the survey was made at an unfavorable stage of water. The Grafton gauge read 14 feet and the St. Louis gauge 19 feet at the beginning of the survey. The river fell until the St. Louis gauge read 7.6 feet on September 24. Then a rapid rise set in and the river reached 16.6 feet on September 30, when the survey was discontinued. However, no low-water period occurred during the summer and fall of that year, and the survey was made at a time about as favorable as could have been chosen. Owing to the high stage of the river the wing dams which have been constructed for the improvement of the river were submerged mostly, and could not be definitely located. These were left to be located at some future time during a low stage of water.

The work was platted in part on a scale of 1 to 5,000, and was afterwards wholly platted on a scale of 1 to 4,800, covering ten sheets of 44 by 72 inches.

The topography shows 5-foot contours, and is ready to be supplemented by outlying topography to be transferred from detail plats of previous surveys, and such other information as may be derived from future supplementary surveys.

The elevations of water surfaces have been reduced to a uniform stage as nearly as could be done in consideration of the rapidly changing stages, and the results have been tabulated and platted.

Soundings were reduced to a mean stage for each sheet. For purposes of preliminary inspection, the approximate channel line and the approximate outlines of pools of 14-foot water, at a low stage, have been placed in pencil on the sheets.

Respectfully submitted.

A. T. MORROW, *Assistant Engineer.*

Capt. WM. B. LADUE,
Corps of Engineers, U. S. Army,
Secretary Mississippi River Commission.

APPENDIX 2.

REPORT OF CAPT. E. W. VAN C. LUCAS, CORPS OF ENGINEERS, ON OPERATIONS IN THE FIRST AND SECOND DISTRICTS.

UNITED STATES ENGINEER OFFICE,
Memphis, Tenn., June 1, 1903.

COLONEL: I have the honor to submit the following report of operations in the First and Second districts, Mississippi River improvement, for the year ending April 30, 1903.

The First district extends from Cairo, Ill., to the foot of Island No. 40, a distance of 220 miles. It includes bank-revetment work at Columbus and Hickman, Ky., and at New Madrid and Caruthersville, Mo.; systematic improvement of Plum Point Reach, Tennessee and Arkansas; abattis dike work; upper St. Francis levee district; Reelfoot levee district, and lower St. Francis levee district to the one hundred and thirty-ninth milepost.

The Second district extends from the foot of Island No. 40 to the mouth of White River, a distance of 175 miles, excepting on the left bank, where it ends at the Coahoma-Bolivar County line (365 L.). This district includes bank-revetment work at Memphis, Tenn., and Hopefield Bend and Helena, Ark.; the improvement of Wolf River, Tennessee; the White River, the Upper Yazoo, and the lower part of lower St. Francis levee districts.

FIRST DISTRICT (CAIRO TO FOOT OF ISLAND NO. 40, 220 MILES).

Columbus, Ky. (21 miles below Cairo, L.).—(For description and previous history, see p. 3580, Report Chief of Engineers, 1891.) This work consists of a series of five spur dikes, protecting 2,200 feet of bank in front of the town. No work has been done since 1890. An examination made this month showed considerable deterioration, the brush above low water having decayed and the intervals between the three lower dikes showing caving about 60 to 75 feet back. This caving can be stopped by mattress revetment between the dikes.

About a year ago some caving occurred along the bluffs just above the town, causing some anxiety in the community, but as the material in the bluff is of hard clay, caving will be very slow, and no immediate danger is apprehended.

Hickman, Ky. (*36 miles below Cairo, L.*).—(For description and previous history see Reports of the Chief of Engineers, 1890, p. 3197; 1895, p. 3756; 1902, Supplement, p. 91.) The bank in front of the city was revetted in 1889, 1892, and 1894 for a distance of 1,560 feet. This revetment is in good condition and no further work is required at present.

New Madrid, Mo. (*71 miles below Cairo, R.*).—(For description and previous history see Reports of the Chief of Engineers, 1894, p. 2859; 1895, p. 3757; 1897, p. 3696; 1899, p. 3504; 1900, p. 4784.) This work consists of 4,500 feet of bank revetment in front of the town, and is generally in good condition, excepting at a few places near the low-water line, where the brush has decayed. It is intended to repair these places by removal of the brush and replacing with standard stone paving, for which purpose the $5,000 allotted by the Commission from the appropriation in the river and harbor act of June 13, 1902, will be applied.

Caruthersville, Mo. (*110 miles below Cairo, R.*).—(For description and previous history see Reports of the Chief of Engineers, 1899, p. 3504; 1900, p. 4384.) This work consists of a revetment protecting the caving bank in front of the town, which at the beginning of the year was 1,890 feet long, with a stone paving up to the 16-foot stage.

During the year, with the allotment of $20,000 from the appropriation in the river and harbor act of June 13, 1902, the paving along the old work was extended up to the 27-foot stage and the mattress revetment was extended downstream 452 feet, increasing the length of revetted bank to 2,342 feet.

This work was begun October 2 and was completed November 30, 1902. One mattress 250 feet wide and 477 feet long was sunk and two connecting mattresses aggregating 88.2 squares were placed in pockets. The bank paving along the old and new work to the 27-foot stage aggregated 5,877.4 square yards. The field cost of the work was $17,173.91. (For further details see report of Assistant Engineer Nolty.)

This revetment is in good condition, the only danger being a small washout hole at the top of the paving, which occurred during the late flood.

Below the revetment the bank is caving slowly at the upper end, but quite rapidly about 1¼ miles below, where a portion of the old levee caved in just after the March flood. Between the latter place and the revetment the present levee is not far from the bank and may soon be endangered if the caving continues. It can, however, be protected by a further extension downstream of mattress revetment.

Plum Point Reach (*147 to 186 miles below Cairo*).—The works of improvement in this reach extend from above Daniels Point to near Craighead Point, Arkansas, a distance of about 20 miles (151–171). These operations began in 1882 and have been fully described in subsequent reports. In general terms, the work done has been the closure of Osceola and Bullerton chutes by pile dikes; the partial closure of Gold Dust Chute by pile dikes and a brush-and-stone dam; the contraction of the low-water channel by dikes at Ashport Bar, Elmot Bar, and Plum Point; the revetment of caving banks above Daniels Point, throughout Ashport and Fletchers bends, along a part of the fronts of Osceola and Bullerton bars, at Plum Point and near Craighead Point; and the construction of levees along both banks of the river.

From funds appropriated by the river and harbor act of June 13, 1902, the Commission allotted $105,000, which it was proposed to expend as follows:

Daniels Point, repairs	$37,500
Ashport Bar, repairs	2,500
Fletchers Bend, repairs	32,500
Osceola Bar, repairs and extension	32,500
Total	105,000

The unfavorable conditions and the high river stages in December, and from February on, prevented the carrying out of this entire programme, and $35,000 was subsequently transferred to plant; $65,715.80 was expended in construction work and the purchase of material, much of the latter being still on hand and available for next season's work.

Daniels Point, Arkansas (*152 R.*).—The bank-protection work at this locality consists of 4,800 feet of fascine mattress revetment at the upper end, built in 1895, below which was 4,000 feet of revetment built in 1889, extensively repaired in 1892, and reenforced at various times thereafter with a number of crib spur dikes. The upper 4,800 feet of revetment is intact, except a small fault in the upper bank work at the lower end, near its junction with the old revetment. Previous to this year's overflow the older work was badly broken along the upper 1,500 feet, large and deep pockets having caved between the main dikes and some of the intermediate dikes having been flanked. Below the dikes was a continuous woven mattress revetment about 1,200 feet long in fairly good condition. Farther down, the revetment, though old and weak, was still effective.

Last year's project contemplated a complete revetment of the pocket between the dikes, as far as funds would permit, but this work was not started because of unfavorable conditions.

A recent examination, made since the subsidence of the flood, shows some enlargement of the pockets between the dikes and two breaks, aggregating about 700 feet, in the continuous revetment below. To make complete repairs at this point will require about 2,700 linear feet of revetment.

Ashport Bend, Tennessee, (*155 L.*).—(For description and previous history see Report of the Chief of Engineers for 1900, p. 4785.) This bend has a continuous revetment 16,540 feet long. Work during the season consisted in making partial repairs to a break in the 1893 revetment in the form of a deep pocket 280 feet long. Because of the general need of the mattress plant elsewhere, work here was not begun until February 6, 1903, when one mattress 155 feet long and 105 feet wide was built and sunk. This repair work could not be completed because of the rise in the river. The field cost was $1,990.72. (For further details see report of Assistant Engineer Nolty.)

This pocket was not enlarged by the recent flood, which, however, did some damage by scouring the bank above the top of the paving, cutting out a number of small pockets along the lower mile of the revetment, which should be repaired before another high water.

Fletchers Bend, Arkansas (*158-161 R.*).—(For description and previous history see Report of the Chief of Engineers for 1900, p. 4786.) This bank has a total length of 17,700 feet of revetment.

The work this season consisted in repairing a break in the 1884 and 1888 revetments immediately below the 1899 work. This break started in 1901 as a narrow break along the low-water line, which was repaired that year with 815 feet of connecting mattresses 40 to 50 feet wide. The paving was also repaired. This work did not stop the caving, which was increased during the 1902 high water to about 1,200 linear feet, involving the entire mattress work and most of the paving. The project last season was to cover the entire break with a complete revetment. Work was not started until December 12 and was prosecuted under continuous and increasing difficulties, due to scarcity of labor, high water, and the difficulty of procuring brush after the bars had been saturated during the December rise. Operations were twice suspended, first by the December rise and its heavy drift and the second time by cold weather and a heavy run of ice, and finally, when work was a little over half finished, the river began rising rapidly and compelled a cessation for the season. One river mattress, 771 feet long by 250 feet wide, and four connecting mattresses, aggregating 211 squares, were sunk, and 1,856 square yards of bank paved. Nine thousand seven hundred and seventy-six yards of stone were stored on the bank for future use. The field cost was $28,522.51. (For further details see report of Assistant Engineer Nolty.)

The mattress was sunk along the lower portion of the break, leaving an unrevetted space above of about 500 feet, which the flood of this year has further enlarged. Other damage by this flood was a cave 1,005 feet long immediately below the mattress sunk this season. This cave has destroyed all paved bank except about 80 linear feet, and extends along the 1888 revetment, which apparently is not effective to prevent caving against the swift current at this locality.

Some scour back of the paving has occurred at the lower end of section A, and the pocket at the junction of this section with section B has enlarged, the point above it caving upstream for about 75 feet. This pocket was never revetted above the low water and it will probably be necessary to hold the point to prevent a serious break.

Osceola Bar (*163 R.*).—The caving bank at the head of this bar was protected in 1895 with a fascine mattress revetment 3,750 feet long. This revetment crosses the two inlets into Osceola Chute and joins the 1884 revetment below. (For further details of this work see Report of the Chief of Engineers for 1896, p. 3600.)

After the 1895 revetment was placed the unrevetted bank above continued to cave, and in 1900 the caving got behind the head of the 1895 mattress, later increasing quite rapidly, and by 1902 had destroyed half of it, and just above the upper inlet to the chute was very close to the main Arkansas shore.

The project for the season's work was to extend the revetment from the uninjured part of the 1895 mattress upstream as far as funds would permit, or practically to cross the upper inlet. With only one revetment plant available, work was delayed until the completion of that at Caruthersville, and operations at Osceola did not begin until November 10. Progress was very slow because of unusual scarcity of labor, and before the mattress was completed a rise in the river caused rapid caving of the unrevetted bank, which cut out the first abutment, and the accumulation of drift above the mattress caused such heavy strains on the anchor lines that it was deemed advisable to sink it at once. The trial was made December 3, and resulted in the loss of the mattress. The eight steel anchor cables either broke or pulled out the trees and other anchorages to which they were fastened, and the mat, thus turned adrift, floated down the river and lodged on a middle bar just below Island 34. This disaster is the first of the kind that has occurred in the reach since 1885.

After this loss, as the river was high, still rising, and full of drift, and the bank caving rapidly, it was considered best to abandon work at this place until more favorable conditions prevailed, and as these did not occur before the close of the season no more work was done. The lost mattress was 637 feet long by 250 feet wide and cost $11,067.74. (For further details see report of Assistant Engineer Nolty.)

Since the high water the channel is much wider than last year because of the scour of the bar opposite; the current is less along the caving bank, and caving has decreased.

The caving now extends 1,200 feet below the upper inlet, and just above the inlet is only about 100 feet from the main Arkansas shore. About 1,500 linear feet of the 1895 revetment still remain in good condition. Below its lower end is an old pocket cave in the 1884 revetment which has recently enlarged both in length and width, having cut under the end of the 1895 work.

The condition of the 1884 revetment along middle Osceola Bar and the later revetment along lower Osceola Bar are practically unchanged.

Other works.—These are generally in effective condition. No enlargement of the breaks in Gold Dust Dam can be observed, and the height of the sand bar covering the Elmot half has materially increased. The discharge from the chute is apparently the same.

All of the Bullerton Bar revetment appears to be in good and effective condition. It is worthy of note that this Bullerton revetment, 10,000 feet long by 250 feet wide, which was built in 1893-94, among the first of the fascine mattresses, has remained in good condition and has required no repair since its construction, which would seem to indicate that the fascine-mattress revetment is an effective type and requires very little for maintenance. The same may be said of the fascine-mattress revetment at all other localities where it has been put in with full width.

ABATTIS DIKES (HERETOFORE KNOWN AS EXPERIMENTAL DIKES).

The object of these dikes is to close secondary chutes and contract the low-water channel by aiding the building up of bars. They have in general been quite successful and may be said to have passed the experimental stage. Dikes of this character have been built opposite Point Pleasant (80 L.), Cherokee (90 R.), Ashport Bar (158 R.), and Elmot Bar (160 L.). They are described in Supplement to Report of Chief of Engineers, 1901, page 235.

The locality selected for this season's work is opposite Hathaway Landing, Tenn. (183 R.). Here the river forms two channels, the main channel along the Tennessee shore and the secondary channel between the Missouri shore and the middle bar, with a crest at 16.8 stage, Cottonwood Point gauge. This divided channel resulted in a shoal crossing, which requires almost constant dredging at low stages.

The project contemplated the closure of the secondary channel by the construction of an abattis dike from the Missouri shore to the middle bar near its head, in order to turn the entire flow during low stages into the main channel.

Work was begun December 12 and completed February 25, after two suspensions, the first due to high water and drift and the second to running ice. Two thousand eight hundred and ten linear feet of dike were built, at a field cost of $14,077.77. (For further details see report of Assistant Engineer Nolty.)

The abattis dikes previously built at Cherokee, Ashport Bar, and Elmot Bar were examined after this year's flood, and all show decided increases in the bars they have formed. This is especially true of the Elmot dikes, where the bar has extended about a mile below the lowest dike.

SECOND DISTRICT (FOOT OF ISLAND NO. 40 TO WHITE RIVER, 175 MILES).

Hopefield Bend, Ark. (*227-230 miles below Cairo, R.*).—This revetment, about 16,600 feet long, extends from Mound City Chute to Hopefield Point and is essential to the maintenance of deep water in Memphis Harbor. It was constructed at various times between 1882 and 1899 and is fully described in the reports of the Chief of Engineers between these dates. (For general description see Report of Chief of Engineers for 1900, p. 4787.)

The upper 5,000 feet of this revetment was built in 1883-84, and consists of a woven mattress 140 to 150 feet wide, with the upper bank covered with brush work to about the two-thirds stage and lightly ballasted with stone. Below this and extending to the more modern revetment of wide mats and paved upper bank is a piece of revetment 1,000 feet long and 175 feet wide, built in 1885.

The upper half of the 1883-84 revetment has been protected for a number of years back by an outlying sand bar, and along its lower half the current was slight until the spring of 1902, when it increased to a marked degree as a result of a change in the river just above, which resulted in the failure of the old revetment which had become weakened by age. One small slip in the 1885 work also occurred at this time.

The flood of this year completed the destruction of the lower 2,400 feet of the 1883-84 work; it also enlarged the previous break in the 1885 work, made another, and practically destroyed the 1885 revetment, at least above the low-water line. This flood also caused some damage to the more modern revetment, the most important item being a break about 500 feet below the head of the paved slope and along the woven mattress of 1891. This break is about 150 feet long, and in the middle extends back nearly to the top of the grade slope. From its present appearance it is thought that only the upper bank is involved and that it can be repaired with a connecting mat and by grading and paving the upper slope.

The other faults, of minor character, consist of slight settling of the bank in three of the paved pockets caused by the flood of 1897 and three small faults in the stone paving above the upper 1897 dike.

There are no indications of failure along the fascine mattresses, which stood the brunt of the extremely swift current at this localily.

It is evident that considerable new work must be done at this place during the coming fall.

Wolf River (*230 L.*).—The object of this improvement is the maintenance by dredging of a navigable channel to the county bridge, 2½ miles above the river mouth. This is done with Government plant and hired labor. (For general description see Supplement to Report of Chief of Engineers, 1902, p. 93, and reports Chief of Engineers, 1893, p. 2136, and 1895, p. 1703.)

The work this season was carried on under an allotment of $10,000 made by the Mississippi River Commission from the appropriation of June 13, 1902. The work was begun August 26 and continued until December 13, when the river became too high, and resulted in the dredging of 42,250 cubic yards of material. A channel was also blasted through a ledge of sand rock and cemented gravel which had been uncovered by previous dredging. This ledge crossed the river with a width of about 200 feet, was 3 to 4½ feet thick, and its high points less than 2 feet below low water.

A cut 200 feet long, 25 to 40 feet wide, and 3 feet deep was made through the ledge by drilling and blasting, at a cost of $570.18. The total cost of the season's work, including office expenses, superintendence, etc., was $6,272.47, making the dredging cost 14.85 cents per cubic yard. There was no very low water during the season, and navigation was easily maintained throughout the year to the county bridge. (For further details see report of Assistant Engineer Rees.)

Memphis Harbor (*230 L.*).—The work at this harbor is the protection of 14,800 linear feet of bank, of which the upper part has been covered by a sand bar. This sand bar extends about halfway down the paved levee and has a width of about 2,200 feet at the mouth of Wolf River. Its low-water area in 1901 was about 106 acres, of which about 8 acres were above the 25-foot stage. Little or no increase was made by the high-water stages of 1902, but this year's flood has completely covered it for about two and one-half months, and it is expected that the next survey will show increases in height and area. There has been no observed extension downstream since 1896. (For further details of this work see reports of the Mississippi River Commission since 1882.)

No work was done this season, and no further work is at present necessary.

Helena, Ark. (*306 R.*).—The work here consists of the protection of 4,900 linear feet of river bank in front of the city. At its head is 1,140 feet of continuous revetment, followed by 1,180 feet protected by a series of four main and two intermediate dikes, below which is a continuous revetment, 2,580 feet long. (For description of the work see Reports of Chief of Engineers, 1890, p. 3212; 1897, p. 3701; 1899, p. 3508, and 1900, p. 4789.)

There has recently been some caving between the dikes, and a general settling for a length of 1,600 feet along the lower revetment, where a continuous crack has developed along about the 25-foot stage, the settlement below the crack ranging from nothing to 5 feet. Farther down the slope, near the low-water line, there is no apparent settlement, and the mattress revetment is apparently undisturbed.

The settling occurred during the low-water stages, when there was a considerable return flow of ground water, which is believed to be the cause, the settling being in the nature of a slough. To remedy this trouble the following project was devised: The construction of a series of blind ditches leading from the crack to the river and filled with brush and stone to afford drainage for the removal of the seep water. For this purpose an allotment of $5,000 was made by the Mississippi River Commission from the appropriation of June 13, 1902, and work was started November 13 and continued until December 3, when high water caused a suspension before the work was completed. Nine ditches were begun and four of them completed to the 8-foot stage, requiring 20 cords of brush and 480 cubic yards of stone; 481 cubic yards of stone are stored on the bank for future work in completing these ditches. The total expenditures were $3,919.40. (For details see report of Assistant Engineer Rees.)

Considerable seep water flowed from the ditches, but whether this will be effective in stopping the settlement will be only determined by future observation.

Owing to the nearness of the levee to the cracked bank it is important to stop any further settlement. It is therefore recommended that the protection work be completed at the first opportunity and as many more ditches cut as may be deemed necessary.

GENERAL REMARKS ON CHANNEL WORK.

The season's work has not been satisfactory because of the small amount accomplished and its high cost. Various causes contributed to handicap the work.

At the beginning of the season the plant was in bad condition and much repair work was necessary before even one revetment outfit could be put in the field. The late passage of the river and harbor bill of June 13, 1902, caused delay in starting repairs, and revetment operations were begun in October with an initial disadvantage of the loss of two months of good working weather in a season that afforded only about four and one-half good months.

From the start the work was embarrassed by the unprecedented scarcity of labor, which continued until December and affected both the Government working parties and those employed by the brush contractors. This labor shortage affected the rate of mat construction, which was only about half of that possible under favorable conditions, and was a direct cause of the loss of the Osceola (Bar) mattress, which was afloat so long that the bank inside caved and cut away the first abutment, while a rising river accumulated at its head so large a quantity of drift that the strain on the moorings proved too great when the attempt was made to sink it.

About the time labor became more plentiful the December rise began, and this not only temporarily stopped operations but by flooding the willow bars the ground was so softened that brush was obtained thereafter with much difficulty.

Of the total of about 4,000 feet of mattress revetment contemplated by last year's projects only about 1,400 feet were built and sunk, while 637 feet were built and lost.

Work of preparation for the coming season is well advanced and the present prospect is that ample equipment will be available for two revetment parties and one dike party by the time favorable working conditions prevail.

LEVEES.

Upper St. Francis levee district (*from opposite Cairo to 70 miles below, R.*).—(For description and previous history, see supplement to report of Chief of Engineers, 1902, page 94.)

When completed this levee will be about 54 miles long, of which 5 miles and 2,000 feet are completed to the Commission standard grade and cross section. The area to be protected by the completed levee is about 700 square miles. No work was done during the year ending April 30, 1903.

The following is a summary of the earth in the levees of this district:

Levees in place April 30, 1903:	Cubic yards.
Erected by the United States	287,198
Erected by local authorities	98,700
Total	385,898

An allotment of $20,000 having been made for this district by the Commission from the 1903–4 appropriation, a contract was entered into with the Shutt Improvement Company for the extension of the levee about 4,000 feet, involving the placing of about 90,000 cubic yards of earth, at 19¼ cents. This extension will close the outlet from Brewer Lake and prevent the drainage of a considerable area, and the local levee board has undertaken to substitute an effective device satisfactory to the Commission. The local levee board has also raised about $10,000 with which they propose to extend the levee as far as possible below the lower end of the new work to be done by the United States. This levee board work will also probably be done during the present season. To complete this levee will require about 5,076,650 cubic yards, at an estimated cost of $861,500, inclusive of the work contracted for this year.

The flood of March, 1903, was 1.6 feet lower than the 1897 flood along this district, which was protected to some extent by the levee already built. The area overflowed is estimated at 275 square miles.

Reelfoot levee district (*36 to 60 miles below Cairo, L.*).—(For description and previous history, see supplement to report of Chief of Engineers, 1902, p. 95.)

This levee when completed will have a length of about 20 miles, of which about 6¼ miles have been completed. The area to be protected by the finished levee is about 310 square miles.

From the funds made available by the river and harbor bill of June 13, 1902, the Commission allotted $20,000 for work in this district. A contract was made with the Memphis Contracting Company, and a new levee was built from station zero (on the high ground at Hickman, Ky.) downstream to station 2/7. The levee was built to a grade of 2 feet below the Commission grade, with a topping of 1 foot. The yardage erected was 141,912, at a contract price 12.40 cents per cubic yard. The total cost to the United States, including office expenses, superintendence, engineering, and contingencies, was $19,358.32, making the final cost per cubic yard 13.64 cents. No work was done by the local levee board during the year.

The following is a summary of the earth in the levees of this district:

Levees in place April 30, 1903:	Cubic yards.
Erected by the United States	141,912
Erected by local authorities	440,710
Total	582,622

During the flood of March, 1903, the lower end of the new work was damaged to some extent between stations 2/0 and 2/7. Practically no protection was afforded by the existing levee, the water coming through the 13-mile gap between its two parts and overflowing the entire district. To complete this levee will require about 1,700,000 cubic yards, at an estimated cost of $255,000.

Under an allotment of $20,000 from the funds to be made available by the sundry civil act of March 3, 1903, a contract was made for continuing the existing levee from stations 4/0 to 5/25, about 110,000 cubic yards, at 14.45 cents. The Fulton County, Ky., Levee Board has contracted for the construction of a levee to close the gap between stations 2/7 and 4/0, and the Lake County, Tenn., Levee Board proposes, with funds now available, to extend the lower end about 1 mile northward during the present season.

Lower St. Francis levee district (*79 to 298 miles below Cairo, R.*).—(For description and previous history, see supplement to report of Chief of Engineers, 1902, p. 95.)

When completed this levee will be about 210 miles long, of which 166 miles have been constructed from Point Pleasant, Mo. (79 R.), to Cat Island, Arkansas (253 R.), and a lower section of 12 miles from 268 R. to 282 R., leaving a gap of 17 miles between the two. An area of 3,500 square miles will be protected by the completed levee.

During the year ending April 30, 1903, the following work was done under an allotment of $125,000 from the appropriation for fiscal year 1902-3:

Stations.	Miles below Cairo.	In place.	Price per cubic yard.	Remarks.
		Cu. yds.	*Cents.*	
Point Pleasant	79	4,382	14.45	New work. Completed.
11/0 to 15/0	92	7,957	15	Enlargement; unfinished. About 172,000 cubic yards to complete.
29/23 to 31/5	112	87,585	15	New work; unfinished. About 32,000 cubic yards to complete.
46/15 to 47/31	128	53,112	15	New work; unfinished. About 147,000 cubic yards to complete.
122/0 to 127/28	208	128,933	14	Enlargement; unfinished. About 51,000 cubic yards to complete.

The total yardage erected was 281,970, leaving about 402,000 cubic yards necessary to complete the contracts. The average contract price is 14.53 cents per cubic yard. All the new work was constructed to a grade 2 feet below the Commission grade, with a topping of 1 foot. All enlargement work was constructed to the Commission grade. During this period the United States expended $46,366.92, including office expenses, superintendence, engineering, and contingencies, making the average cost per cubic yard 16.44 cents.

In addition to the above work done by contract, the United States placed on the Caruthersville loop during the high water 5,917 cubic yards between stations 30/5+25 and 30/27+20. This work cost $8,482.74, or $1.434 per cubic yard.

No levee has been built by the St. Francis levee board of Arkansas, during the period covered by this report. Their expenditures have been as follows for the same period:

For maintenance of levee, engineering, right of way, drainage, surveys, etc	$12,576.92
For salaries, assessors, materials, tax collectors, etc	12,949.96
For interest on bonds and certificates	50,999.25
	76,526.13

During the period from May 1, 1902, to April 30, 1903, earth was added to the levee as follows:

	Cubic yards.
By the United States	281,970
By local authorities	-------
Total	281,970

There were lost or abandoned on account of caving banks, new loops, and crevasses, which occurred during the high water of March, 1903, the following portions of the levee, constructed in part by the United States and in part by the levee board:

Stations.	Miles below Cairo.	Length.	Cubic yards.	Put up by United States.	Put up by levee boards.
		Feet.		*Cubic yds.*	*Cubic yds.*
29/23+35 to 31/5+13 (loop)	111	8,738	120,000	73,000	47,000
46/15 to 47/31 (loop)	127	6,880	130,000	56,000	75,000
Random Shot crevasse	194	535	8,300	....	8,300
Hollybush crevasse	219	2,410	44,470	....	44,470
Walnut Bend (caving)	281	835	17,700	17,700	....
Total	....	19,398	320,470	145,700	174,770

The following is a summary of the earth in the levees of this district:

	Cubic yards.
Put up by the United States and in place April 30, 1902	4,408,867
Added from May 1, 1902, to April 30, 1903 (by contract)	281,970
Added by United States force, work during high water, 1903	5,917
Total	4,696,754
Lost or abandoned during the year	145,700
In place April 30, 1903	4,551,054
Put up by levee boards and others and in place April 30, 1902	9,588,814
Lost or abandoned during the year	174,770
In place April 30, 1903	9,414,044
Levees in place April 30, 1903:	
Erected by the United States	4,551,054
Erected by the local authorities	9,414,044
Total	13,965,098

During the flood of March, 1903, breaks occurred at Random Shot, on levee mile 108–9, with a width of 535 feet, and at Hollybush, where the levee was overtopped by the water for 1½ miles, on levee miles 141–2, resulting in four breaks aggregating 2,410 feet. The area overflowed is estimated at 1,250 square miles, of which about 215 square miles was due to crevasses, and the remainder to overflow through the 17-mile gap below Cat Island, and to backwater from the mouth of St. Francis River.

To complete this levee to the Commission standard grade and cross section will require about 10,217,000 cubic yards, at an estimated cost of $1,532,000. This does not include closing the above-mentioned breaks.

Under the allotment of $125,000 from the appropriation of fiscal year 1903–4 contracts have been made as follows:

Stations.	Enlargement.	Cost per cubic yard.
	Cub. yds.	*Cents.*
5/8 to 8/0	116,000	12.89
8/0 to 11/0	104,000	16.48
15/0 to 17/0	75,000	17.00
51/0 to 51/42	30,000	13.98
127/28 to 130/0	115,000	16.94
130/0 to 134/0	120,000	16.94

The St. Francis levee board of Arkansas proposes to expend during the coming season about $500,000 in closing the breaks made by the flood of March, 1903, to close the 17-mile gap below Memphis, and to enlarge the existing levee for about 25 miles north of Memphis.

White River levee district (*306 to 385 miles below Cairo, R.*).—(For description and previous history see Supplement to Report of Chief of Engineers, 1902, p. 97.)

The length of this levee is 74 miles, of which 64 miles are controlled by the United States. There are still open in this line four breaks made by the 1897 flood, aggregating about 10,000 feet in length and all located within the 6 miles below Modoc Landing (335 R.). The area to be protected by this levee when completed is about 910 square miles.

Under the allotment of $90,000 made from the appropriation for 1902–3 the following work has been done:

Stations.	Miles below Cairo.	In place.	Price per cubic yard.	Remarks.
		Cub. yds.	*Cents.*	
1/49 to 3/0	308	47,331	18.95	Enlargement; unfinished. About 42,700 cubic yards to complete.
17/49 to 18/48	324	29,582	15.85	Enlargement; unfinished. About 30,400 cubic yards to complete.
28/0 to 29/0	336	4,247	16.89	New work; unfinished. About 145,700 cubic yards to complete.
37/32 to 38/34	344	30,913	18.95	Enlargement; unfinished. About 29,000 cubic yards to complete.
47/38 to 48/3	363	51,168	19.9	New work; completed.

The total yardage erected was 163,241, leaving about 247,800 cubic yards necessary to complete the contracts. The average contract price was 18.63 cents per cubic yard. The grades to which the above work was constructed were from 1 to 2¼ feet below the Commission standard.

The amount expended by the United States, including office expenses, engineering and contingencies, was $35,742.98, making the final cost 21.89 cents per cubic yard.

During the year the local authorities have repaired and enlarged mile sections 1, 2, 3, and 5 to 28, inclusive, erecting 47,566 cubic yards, and have expended $19,402.39, the expenditures including right of way, engineering, and office expenses, etc.

During the period from May 1, 1902, to April 30, 1903, earth was added to the levee, as follows:

	Cubic yards.
By the United States	163,241
By local authorities	47,566
Total	210,807

During the same period 1,800 feet of levee were abandoned on account of construction of a new loop from stations 47/38 to 48/3. The levee abandoned had been constructed in part by the United States and in part by the local levee boards, and contained 30,060 cubic yards.

The following is a summary of the earth in the levees of this district:

	Cubic yards.
Put up by the United States and in place April 30, 1902	6,085,484
Added from May 1, 1902, to April 30, 1903	163,241
Total	6,248,725
Abandoned during the year	20,000
In place April 30, 1903	6,228,725
Put up by levee boards and others and in place April 30, 1902	1,452,734
Added from May 1, 1902, to April 30, 1903	47,566
Total	1,500,300
Abandoned during the year	10,060
In place April 30, 1903	1,490,240
Levees in place April 30, 1903:	
Erected by the United States	6,228,725
Erected by local authorities	1,490,240
Total	7,718,965

The levee in this district is generally low, particularly in the lower half of the district, where the greater part was below the recent flood and had to be topped, and until the levee is considerably enlarged it is not deemed advisable to close the 1897 breaks. During the recent flood the water coming through these breaks overflowed about 768 square miles.

On March 25, 1903, a crevasse occurred in the private levee in rear of the Laconia Circle loop at milepost 69/70. This break is 480 feet long and about 6,000 cubic yards of levee was destroyed. This quantity was not included in the table above, as the levee in which the break occurred is not considered a part of the regular system.

To close the gaps caused by the 1897 flood and construct the levee to the Commission standard grade and cross section, including a new loop back of Beiths Landing (367 R.), will require about 8,680,000 cubic yards at an estimated cost of $1,736,000, including engineering expenses and contingencies. This estimate does not include any work on the private levee back of the Laconia Circle.

Under an allotment of $90,000 from the appropriation for 1903-4 work has been let as follows: From stations 3/0 to 4/7, enlargement, 60,000 cubic yards, at 17.7 cents. From stations 27/0 to 64/40, enlargement and new work, 350,000 cubic yards, at 14.94 cents.

Contracts for the last-mentioned work have not yet been executed.

Upper Yazoo levee district (244 to 365 miles below Cairo, L.).—(For description and previous history see supplement to Report of Chief of Engineers, 1902, p. 98.) This district has 124 miles of levee, protecting an area of 3,281 square miles.

Under an allotment of $70,000 from the appropriation for 1902–3, a contract was made for a piece of new levee from stations 118/10 to 120/11 (356 miles below Cairo), and 128,947 cubic yards erected at a contract price of 16.7 cents per cubic yard, leaving 231,000 cubic yards still to be placed to complete the contract. This work was built to about 2 feet below the Commission standard grade and cross section, and the total cost was $23,346.95, including office expenses, superintendence, and contingencies. The final cost per cubic yard was 18.10 cents.

In addition to the above work the local levee board enlarged and repaired the levee on mile sections 8, 9, 10, 14, 15, 20, 21, and 81 to 87, inclusive, doing in all 575,400 cubic yards, at an average contract price of 18.92 cents per cubic yard. The contract cost of this work was $132,034.43, and the total expenses of the levee board during the year, including right of way, drainage, engineering, and contingencies were $277,667.57.

During the period from May 1, 1902, to April 30, 1903, earth was added to the levee as follows:

	Cubic yards.
By the United States	128,947
By the local levee boards	575,400
Total	704,347

None of the existing levee was lost or abandoned during the year on account of caving or from other causes.

The following is a summary of the earth in the levees of this district:

	Cubic yards.
Put up by the United States and in place April 30, 1902	6,114,986
Added from May 1, 1902, to April 30, 1903	128,947
Total	6,243,933
Put up by the levee board and others and in place April 30, 1902	14,053,545
Added from May 1, 1902, to April 30, 1903	575,400
Total	14,628,945
Levees in place April 30, 1903:	
Erected by the United States	6,243,933
Erected by local authorities	14,628,945
Total	20,872,878

The levee of this district is in very good condition, being completed to at least the standard cross section and to a grade not more than 2 feet below the Commission standard grade. It is estimated that the amount of earth required to raise and enlarge this levee to the Commission standard grade and cross section is about 6,800,000 cubic yards, at an estimated cost of $1,224,000.

Under an allotment of $90,000 from the appropriation for 1903–4, contracts have been made for the construction of about 350,000 cubic yards of enlargement work at 18.87 cents per cubic yard.

The work of protecting this levee during the flood of March, 1903, was done entirely by the local board, the Government furnishing only a quarter boat, a barge, and the services of an assistant engineer.

GENERAL REMARKS ON LEVEE WORK.

Of twelve contracts made during the year for new or enlargement work on levees, eleven of which were to have been completed by January 31 last, only one is finished. The contractors generally had to meet exceptionally unfavorable conditions, including scarcity of labor, rainy weather, and three high river stages.

The total amount of work done by the United States during the year in the First and Second districts was 716,170 cubic yards, at an average contract price of 15.43 cents per cubic yard and an average price of 17.43 cents per cubic yard, including engineering, contingencies, etc.

To complete the levees in the First and Second districts to the Commission grade and cross section, allowing for work now done and for work not yet done but provided for under the appropriations for 1902–3 and 1903–4, will require about 30,000,000 cubic yards of material, at an estimated cost of about $5,000,000.

A map in four sheets is submitted herewith showing the existing levees of the First and Second districts and the localities where work has been in progress during the year, both by the United States and by local authorities.

OVERFLOWS.

Two overflows occurred during the year.

The first and serious one began early in March and was the result of high water in the upper Mississippi, the Ohio and its tributaries, and the White and Arkansas rivers.

It being evident about the 1st of March that a serious overflow was imminent, preparations were made for protecting the levee lines as much as possible from damage. Active operations began in the lower St. Francis district on March 7, when the Cairo gauge read 44.3 feet, with a daily rise of 1.1 feet. The river at Cairo was above the danger line—45 feet—from March 8 to 27, and reached a maximum of 50.6 feet on March 15, remaining there for three days. The maximum was 1 foot below the 1897 high water and 1.6 feet below that of 1882, the highest on record.

The river at Memphis reached the danger line—33 feet—on February 22, and continued above until April 5, attaining on March 20 a maximum of 40.1 feet, 2.4 feet above the highest previously recorded stage of 37.7 in 1897, which was exceeded from March 15 to March 29 of this year. This increased flood height was evidently due to the extension since 1897 of the St. Francis levee from Pecan Point to Cat Island, about 20 miles below Memphis.

At Helena, Ark., the river reached the danger line—42 feet—on February 22, and continued above until April 13, attaining on March 26 a maximum of 50.1 feet, eight-tenths foot below the 1897 high water.

General.—A general oversight of the levee protection work in the various districts was maintained from the Memphis office, the base of supplies. During the continuance of the fight the Government steamer *Chisca* was used for general inspection and supply purposes, and at the height of the flood the Government steamer *Minnetonka* was also utilized a few days for the same purpose. This work of oversight was carried on by Principal Assistant Engineer Rees and myself, one being always at the office and the other generally on the river looking after the delivery of supplies and inspecting the work.

Upper St. Francis district.—In this district the jurisdiction of this office begins at Birds Point, opposite Cairo, below which are only about 5 miles of levee, with an unclosed gap lower down of nearly 50 miles. No protective measures were necessary, none were taken, and no damage to the levee resulted from the flood, although about 275 square miles within the proposed levee line were flooded.

Reelfoot district.—About 2 miles of levee had been constructed from the upper end and about 4½ miles from the lower end, leaving a gap between of about 13 miles. The levee at the upper end was new and unsodded and efforts were made to protect from erosion, in spite of which the sides of the levee were badly washed along the lower 500 feet and considerable material lost by the swift current whipping around its end. This levee afforded practically no protection, the entire area of 310 miles to be protected by the completed line being overflowed.

Lower St. Francis district.—The St. Francis levee board of Arkansas having undertaken to protect the 63 miles of levee below Pecan Point, and the Walnut Bend levee below, the defense of the 110 miles above Pecan Point was undertaken by this office. The levee board was, however, furnished with a Government boat equipped with crew and supplies for inspection purposes and delivery of material.

First division (78 R. to 196 R.).—The protection of this part was managed from this office, the levee being divided into sections of approximately 20 miles, each in charge of an inspector having authority to employ as need arose the force necessary for its proper defense. The entire division, containing 110 miles of levee, was under the general supervision of Assistant Engineer Nolty, who was constantly patrolling the entire line, supervising the inspectors' work and furnishing them with necessary material. For patrol purposes he used the Government steamer *Graham.* The levee in this division was in fairly good condition, its top being 1 to 4 feet above the flood height, excepting at the lower end. There were, however, a number of weak places, notably at Luxora and Random Shot, Ark., and only by constant attention and hard work was this levee kept from breaking in many places, and in spite of all efforts a blowout occurred at Random Shot, at an old bayou crossing, about 40 feet of the levee being undermined. Subsequent erosion at the ends increased the width to 535 feet.

At Caruthersville, Mo., the old levee was of ample height and cross section, but close to a caving bank. In anticipation of its loss, a contract was made in August, 1902, for a back loop which had not been completed, there being a gap of 1,200 feet with little or no embankment. Caving continued as the river rose in February, and it being evident that the old levee could not be depended on throughout the overflow, the raising of a temporary embankment in the 1,200 feet gap of the new loop was undertaken by this office, with the assistance of the St. Francis levee board of Missouri and the Chicago Mill and Lumber Company, the latter corporation having large milling interests protected by this levee. Work on the embankment was prosecuted under most unfavorable weather conditions, and much material had to be moved by wheel scrapers a quarter of a mile or more to within 100 yards of the levee, from which point it was carried to the embankment by wheelbarrows. Later a tram road was built along the completed levee for delivery of material. Over 5,000 cubic yards of earth were placed and the embankment raised to a level about 2 feet above that attained by the flood. During the continuance of the work the old levee caved in three places, but these caves were anticipated and the entrance of the water prevented by small loops. The old levee so repaired lasted until after the subsidence of this flood, when extensive bank caving occurred and several hundred feet of levee were lost. During the second rise in April the river water came through this break in the old levee, and the embankment in the gap of the new loop was all that prevented material damage.

The Caruthersville work was under the immediate charge of Asst. Engineer A. F. Kilpatrick.

The cost of high-water protection on this division, including that at Caruthersville, which was unusual, was as follows:

Expended by the United States	$29,497.90
Expended by the Missouri Levee Board	7,750.00
Expended by the Chicago Mill and Lumber Company	5,000.00
Expended by the town of Luxora, Ark	43.50
Total	42,291.40

Second division (196 R. to 282 R.).—Protection work on this division was undertaken by the St. Francis Levee Board of Arkansas, the Government furnishing the small steamer *Abbott*, with crew and supplies, for use as an inspection boat and tender.

The flood found the levee of this division in good condition, but deficient in height. It was constructed with reference to the 1897 flood level, but the subsequent closing in of the flood area caused a material increase in height, and the levee was overtopped in many places, overflows being generally prevented by raising the levee with earth topping, sacks filled with earth, and similar expedients. At Hollybush Landing, about 15 miles above Memphis, the working parties were driven off by the water flowing over the levee for a distance of 1¼ miles on levee miles 141-2, the result being four cuts, aggregating 2,410 feet. The president of the levee board informed me the next day that failure to hold this part of the levee was due to their inability to obtain at the critical time labor previously promised them. At the time of these breaks the gauge at Memphis read 39.6 feet, and as a result the Memphis gauge fell two-tenths within twelve hours, but rose again the same amount the succeeding twelve hours, and reached its maximum of 40.1 feet five days after the breaks. The cost to the levee board for the protection work on this division was $23,000.

The total area overflowed in the St. Francis district was 1,250 square miles, of which about 215 square miles was due to the breaks, the remainder being the result of the water passing through the 17-mile gap between Cat Island and Walnut Bend levee, and of the back water from the mouth of the St. Francis River. The cost of high-water protection in the entire district was as follows:

Expended by the United States	$29,497.90
Expended by the local boards	30,750.00
Expended by others	5,043.50
Total	65,291.40

Upper Yazoo Levee district (244-365 L.).—The defense of this levee was undertaken by the local board, the only Government assistance provided being a quarterboat, a barge, and the services of Asst. Engineer M. Gardner.

The levee of this district was generally in excellent condition, except at Malones Landing, where a salient was located on the caving bank. Anticipating its loss, a contract was made last fall for a back loop at this place, which had not been completed on account of the unfavorable conditions. In January and February a temporary loop was constructed containing 40,000 cubic yards, at a cost of $10,421, of which $1,221 was paid by the United States and $9,200 by the levee board. This temporary loop probably prevented a serious crevasse. Four dangerous places developed during the flood near Burks Landing (333 L.), on the Ward Lake levee (337 L.), at the end of the front levee on mile 90 (340 L.), and near Malones Landing (356 L.). There were a number of boils and seeps and at times troublesome wave wash, but nothing to cause very serious apprehension. No breaks occurred. The amount expended by the levee board in protecting work outside of the temporary loop at Malones Landing was $43,973.13.

White River levee district (306–385 R.).—The line of levee in this district is divided into two parts by the still open 1897 breaks. The entire defense was undertaken by this office, with valuable assistance from the local boards. The upper 28 miles from Helena, Ark. (306 R.), to Modoc, Ark. (335 R.), was in charge of Asst. Engineer C. H. Purvis, with the chartered steamer *Atlee* as tender. The lower 42 miles from the Dixie break (341 R.), to and including Laconia Circle, was in charge of Asst. Engineer Charles Le Vasseur, with the U. S. S. *Mercury* as tender.

From milepost 16 to the lower end of the levee the grade is generally low and the cross sections weak. Most of the work done consisted of raising the crest by means of earth-filled sacks, earth topping and planks backed with earth. Numerous bad seeps, boils, and sloughs occurred and in many places crevasses were prevented only by continuous effort.

No breaks occurred in the United States levee, but on March 25, when the Helena gauge read 50.9 feet, a break occurred in the private levee behind the Laconia Circle. This break was due to seeps and boils and attained a maximum width of 480 feet. As a result the farms inside of Laconia Circle were flooded to an average depth of 12 feet, and it was necessary to retop 7 miles along the lower end of the loop to prevent the destruction of the levee by water flowing over from the inside. This retopping was successfully accomplished, however, and no further breaks occurred.

Aside from the Laconia Circle, the area overflowed in this district was due to the 1897 breaks, and amounted to 768 square miles. The flood was considerably higher in this part of the district because the White and Arkansas rivers were exceptionally high during the entire period of the Mississippi flood. The cost of high-water protection of this levee was as follows:

Expended by the United States	$21,628.36
Expended by the local levee boards	9,759.72
Total	31,388.08

Total flood expenses.

	By United States.	By others.	Total.
Reelfoot district	$155.61		$155.61
Lower St. Francis district	[a] 29,497.90	[b] $35,793.50	65,291.40
Upper Yazoo district	466.25	43,973.13	44,439.38
White River district	21,628.36	9,759.72	31,388.08
Total	[a] 51,748.12	[b] 89,526.85	141,274.47

[a] $8,482.74 of these amounts spent on Caruthersville work.
[b] $7,100 of these amounts spent on Caruthersville work.

General notes on the flood.—The extension of the lower St. Francis levee from Pecan Point (196 R.) to Cat Island (253 R.) and the extension northward of the Walnut Bend levee have changed the flood conditions at and above Memphis and in the vicinity of Walnut Bend. This has to be taken into consideration before making a comparison between the present flood and those of preceding years. Prior to 1897 the bottom lands of the St. Francis Basin were flooded more or less whenever the river at Cairo reached a stage between 41 and 42 feet. During the 1897 flood 28 crevasses occurred, 13 with an aggregate discharge of about 95,000 cubic feet per second in the lower St. Francis, one with a discharge of 73,000 cubic feet in the upper Yazoo, and 14 with aggregate discharge of 192,200 cubic feet in the White River district. During the 1903 flood only two breaks occurred in the lower St. Francis district, four of the 1897 breaks were open in the White River district, and th upper Yazoo escaped without any.

In the following table a comparison is made of several earlier floods with that of this year.

Year.	Cairo, Ill., maximum stage.	Fulton, Tenn.		Memphis, Tenn.		Helena, Ark.	
		Maximum stage.	Below Cairo gauge.	Maximum stage.	Below Cairo gauge.	Maximum stage.	Below Cairo gauge.
1882	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
1883	51.8	36.7	−15.1	35.0	−16.8	47.2	−4.6
1884	52.2	36.3	−15.9	34.8	−17.4	46.9	−5.3
1886	51.8	35.7	−16.1	34.2	−17.6	47.0	−4.8
1897	51.0	35.4	−15.6	34.8	−16.2	48.1	−2.9
1898	51.6	37.4	−14.2	37.7	−13.9	51.5	− .1
1903	49.8	38.3	−11.5	37.2	−12.6	49.1	− .7
	50.1	40.0	−10.0	40.1	−10.0	51.0	+ .9
Average differences			−14.06		−14.93		−2.5

The average differences in stages during the floods to 1886, inclusive, were between Cairo and Fulton, 15.7 feet; Cairo and Memphis, 17 feet; and Cairo and Helena, 4.4 feet. The construction of the levees between 1886 and 1897 caused a decrease in the average differences between these points to 15.4, 16.4, and 3.54, respectively. After the 1898 flood the average differences decreased to 14.73, 15.75, and 3.07, and after the 1903 flood to 14.06, 14.93, and 2.5, showing plainly the effect of the closure of the basins by the levees.

At Columbus, Ky. (21 L.), and Helena, Ark. (306 R.), the maximum discharges were:

Year.	Columbus, Ky.	Helena, Ark.
	Cubic feet.	*Cubic feet.*
1882	1,521,139	1,562,240
1897	1,462,347	1,486,222
1898	1,516,609	1,424,643
1903	1,380,000	1,450,000

The following table shows flood effects in 1903 and previous years:

LOWER ST. FRANCIS LEVEE (166 MILES).

Year.	Overflowed area.	Length of crevasses.	Total length of levee line built.	Remarks.
	Sq. miles.	*Feet.*	*Miles.*	
1882	3,308			District not protected by levees until after 1893. Before 1897, 115 miles built. After 1897, 51 miles built.
1893	3,308			
1897	2,595	13,405	115	
1898	1,100		122	
1903	1,250	2,945	166	

UPPER YAZOO LEVEE (124 MILES).

1882	3,281	37,000	117	Old low levee.
1884	3,281	37,000	117	Do.
1886	98	3,000	124	Old crevasses closed and levee enlarged.
1890	50	500	124	
1891	17	600	124	
1892			124	
1893			124	
1897	342	2,025	124	Flower Lake crevasse.
1898			124	
1903			124	Levees are in good condition and 1 to 4 feet above 1897 high-water line.

NOTE.—Levees strengthened each year 1884-1897 by enlarging section and raising grade. In 1897 a considerable part was still below grade.

WHITE RIVER LEVEE (74 MILES).

Year.	Overflowed area.	Length of crevasses.	Total length of levee line built.	Remarks.
	Sq. miles.	*Feet.*	*Miles.*	
1882	900	10,000	20	Low grade.
1884	850	1,000	22	Do.
1886	500		30	Built to high grade.
1890	600	8,000	30	
1891	500		37	
1892	400		41	
1893	400		46	
1897	900	16,420	74	Including Laconia Circle.
1898	768		74	The Modoc breaks (1897) still open.
1903	768	10,480	74	Including Modoc and rear Laconia breaks.

Lower St. Francis district.—The numerous breaks in 1897 made the high-water record of that year to some extent imperfect, but the flood of 1898, passing along an unbroken front, permitted the determination, from a careful record of its greatest heights, of an approximate high-water grade, which has been a valuable guide to the solution of the problem of a proper levee grade, and since 1897 the low levees from Point Pleasant to 128-mile post have been enlarged and raised to the extent possible with allotments made.

The extensions of the system southward raised the flood line above and in the immediate vicinity of Memphis, Tenn. This flood has apparently demonstrated that the previously adopted grades, from Fulton (175 L.) to the Choctaw, Oklahoma and Gulf Railroad embankment (235 R.) are too low to stand a flood of the same magnitude. The grade of this part of the system will probably have to be raised 3 to 4 feet.

The percentages of levee above and below the 1903 flood line are shown in the following table:

	Feet.	Per cent.	Miles.
Above 1903 high water	5	9.90	16.44
Do	4	15.66	26
Do	3	28.14	46.72
Do	2	21.09	35
Do	1	13.52	22.44
Do	.5	4.55	7.55
High water 1903	.0	6.02	10
Below 1903 high water	.5	.30	.50
Do	1	.30	.48
Do	4	.22	.37
Do (Osceola)	6	.30	.50

Upper Yazoo district.—The levees in this district stood well above the 1903 high-water line, but it should be noted that the 17-mile gap in the Lower St. Francis levee system between Cat Island (235 R.) and Bledsoe (268 R.) and the still existing 1897 breaks in the White River system below Modoc (335–341 R.), exercised a marked influence in the heights attained along the adjacent parts of the Yazoo levees.

The construction of the St. Francis levee from Memphis to Cat Island raised the water line on the upper part of the Yazoo system during the past flood, and it is certain that with a continuous line of levee in the St. Francis and the closure of the breaks below Modoc, the heights of the levees in this district above the 1903 flood will be considerably decreased and that part of the system will have to be raised and enlarged; but the local board is well equipped for doing effective work, and it is safe to assume that by the time the levees on the Arkansas side are built to a safe grade and cross section the Upper Yazoo system will be able to stand the increased flood.

The present condition of the levees in this district is shown in the following table:

	Feet.	Per cent.	Miles.
Above 1903 high water	4	17.7	22
Do	3	42.7	53
Do	2	19.4	24
Do	1	13.7	17
		[a]6.5	8

[a] The water does not get against this levee on account of it being above the Ward Lake junction.

This levee has 1½ to 2 feet topping in addition to above grades.

White River levee district.—Since the construction of the levees in this district the observed heights attained by floods prior to 1903 were of little value and the many breaks in the levee line during the 1897 flood afforded no reliable basis for fixing levee grades. This year, while a considerable volume of water escaped through the 1897 breaks, the front line stood the pressure of the maximum stage and valuable information as to the required grade was obtained.

It is certain, in view of the work necessitated during the high-water period, that nearly the entire line is too weak and the grade too low to warrant the present closure of the 1897 breaks, and that even with these breaks left open most of the levee below mile 16 must be raised about 3 feet and many places will have to be enlarged to stand an equivalent flood.

The following table shows the present condition of this levee:

	Feet.	Per cent.	Miles.
Above 1903 high water	4	4.4	3
Do	3	8.8	5.99
Do	2	9.2	6.24
Do	1	27.3	18.59
Do	.5	10.8	7.33
High water 1903	.0	20.7	14.11
Below 1903 high water	.5	11	7.49
Do	1	5.6	3.79
Do	2	2.2	1.46

The second overflow: After the March flood the river fell to 36 at Cairo April 10, 28.5 feet at Memphis April 14, and 41.4 at Helena April 15. A second flood wave from the Ohio, Tennessee, and Cumberland rivers raised the gauge reading to 45.2 at Cairo April 23, 34.4 at Memphis April 30, and 44.4 at Helena May 2.

The second flood caused no great damage to the country already overflowed, excepting by delaying farming operations, but just after the March flood the lower St. Francis levee was cut at different places by the local authorities to drain the water accumulated just behind them. When the April flood came the water entered these cuts, enlarging them and making deep crevasses. The Random Shot break was also enlarged by this second flood, its present width being 862 feet. The Hollybush breaks were not materially enlarged.

Damage due to flood.—Although the maximum height of the 1903 flood was greater throughout most of the district than that ever before attained, the resulting damage to property and the area overflowed were both less than in 1882 or 1897. This is a natural consequence of the nearer approach to completion of the levee system in the first and second districts and the fewer number of breaks, two in 1903, as compared with 28 in 1897.

The damage to farm lands, aside from the inconvenience and delay consequent on every flood, was comparatively small. Planting operations had hardly started at the beginning of the flood and were of course delayed, but farm lands generally can be planted in time to yield good crops this season. The loss of stock was comparatively small, as the planters generally had made preparations to protect it when the overflow became imminent. The principal damage to farms apparently consisted in the loss of stock, fences, and small cabins.

The principal item of damage in the first and second districts appears to have been suffered by the railroads crossing the delta from the Memphis bridge. The three systems, the Frisco, Choctaw, Oklahoma and Gulf, and the Iron Mountain and St. Louis railroads suffered direct loss in the way of damage to roadbed and track, and indirect loss due to a ten days' suspension of traffic. These railroad losses were directly due to the breaks in the levee at Hollybush and Random Shot, the overflow from which cut the railroad embankments a few miles west of Memphis. The Illinois Central Railroad, located on the east side of the river, suffered some damage and suspension of traffic above and below this city on account of the overflow of their tracks due to the unprecedented high water at this place. An effort has been made to obtain from the railroads an estimate of the direct and indirect damage to their systems caused by the flood, but they have been unable to furnish the data in time for this report.

The towns and cities along the river all suffered more or less damage from high water, the principal item being at Memphis, where about 75 acres in the northern part of the city were flooded to a maximum depth of 6.5 feet.

It is roughly estimated that the total damage due to the flood in the First and Second districts would amount approximately to between $500,000 and $600,000, of which probably half was suffered by the railroads. To this should be added the cost of levee protection during the high water, $141,000, paid by the United States and various levee boards and others interested.

A map showing the territory overflowed and high water and levee profiles for the First and Second districts are submitted herewith.

SURVEYS.

During the year ending April 30, 1903, the following surveys and examinations were made:

General survey of Memphis Reach from foot of Island No. 40 to 300 meters below the Memphis Railroad bridge.

Detailed survey of Memphis bar from above Wolf River to foot of Beale street.

Detailed survey of Hopefield Bend, Ark., from 200 meters above Mound City Landing to Hopefield Point.

Detailed survey of the Mound City (Hopefield Bend) caving bank.

General survey of Plum Point Reach from head of Island No. 26 to Fort Pillow Landing.

Detailed survey of Ashport bar, Ark., at site of abattis dike.

Detailed survey of Elmot bar, Tenn., at site of abattis dikes.

General topographical survey of Walnut Bend territory between the Mississippi and St. Francis rivers.

High-water survey of levees to obtain data relative to flood of March, 1903.

PLANT.

In consequence of the failure of the proposed 1901 river and harbor bill no funds were available to repair the deterioration of the previous or current years until last July. As a result, when the appropriations made by the 1902 bill became available the plant was in very bad condition, and the season was so far advanced that the only work attempted last summer was that necessary to put one revetment plant and one dike plant in the field.

From funds appropriated by the river and harbor act of June 13, 1902, the Commission allotted $70,000 to care of and repairs to plant, which amount was increased in March, 1903, by the transfer of unexpended balances of $35,000 from Plum Point Reach allotment and of $4,000 from the allotment for experimental dikes.

In addition to the repair work above mentioned (much of it temporary) the following has been done during the past year:

Repairs to hulls of steamer *Abbot*, pile driver No. 8, quarterboats Nos. 11, 25, 39, 206, and 221, 7 gunwale barges, 2 model barges, 2 mattress barges.

Two flats 50 by 15 feet were built to replace old and unserviceable ones, a new cabin was built on the steamer *Graham*, and the dredge *Wolf* was docked and repaired.

The expenses for the year ending April 30 were as follows:

Repairs to plant	$57,719.28
Purchase of property	874.02
Care of plant	11,794.96
Total	70,388.26

As a result of the season's work much of the plant has been repaired and is in thoroughly good condition, although many pieces still require extensive repairs, while a few are not worth repairing and await condemnation.

The following is a statement of the plant on hand, either in serviceable condition, or, if unserviceable, worth repairing:

Plant.	On hand.	Serviceable.	Unserviceable and worth repairing.
Barges	34	13	21
Mat barges	8	2	6
Mooring barges	2		2
Quarterboats	12	5	7
Pile drivers[a]	2	1	1
Grader	1	1	
Steamers (towboats)	3	2	1
Steamers (small tenders)	2	2	
Dredges	1	1	
Dump scows	2	2	
Flats, 50 feet	2	2	
Machine shop (floating)	1	1	
Floating dock	1	1	

[a] These pile drivers belong to the improvement of the Mississippi River above Cairo.

Unserviceable plant awaiting condemnation: Two barges, 2 mattress barges, 3 50-feet flats, 1 machine-shop barge.

Of the three steamers (towboats), the *Chisca*, while serviceable, requires considerable repair and will be hauled out at Paducah. Necessary repairs to the *Graham* (serviceable) will be made in the floating dock here. The steamer *Titan* (unserviceable) will be hauled out at Paducah and repaired in time for the coming season's work.

Repair work on plant at present unserviceable will be continued with the balance of last year's allotment and $15,000 already allotted from the appropriation of 1903–4. Twelve thousand dollars additional will be needed for care of plant during the year, and an additional allotment of $48,000 will be needed to complete the equipment of sufficient plant to put in the field two revetment parties and one dike party. No new plant has been purchased or built for these districts since 1894. (For further details see report of Asst. Engineer A. J. Nolty on plant.)

INCLOSURES.

The following inclosures accompany this report and form part of it:

Money statements.

Abstract of contracts in force April 30, 1903.

Appendix 2 A.—Report of Asst. Engineer A. J. Nolty on operations at Hathaway Crossing, Caruthersville, Mo., and Plum Point Reach.

Appendix 2 B.—Report of Asst. Engineer W. M. Rees on operations in Wolf River, Tennessee, and at Helena, Ark.

Appendix 2 C.—Report of Asst. Engineer A. J. Nolty on care of and repairs to plant.

Appendix 2 D.—Report of Asst. Engineer A. J. Nolty on operations during the high water of 1903.

Appendix 2 E.—Report of Asst. Engineer Charles Le Vasseur on operations during the high water of 1903.

Appendix 2 F.—Report of Asst. Engineer M. Gardner on operations during the high water of 1903.

Map of Plum Point Reach.

Map of Memphis Reach.

Map of Helena Reach.

Map showing existing levees first and second districts (4 sheets).

Map showing territory overflowed during 1903 flood.

Profiles of levee and high water slopes.

Map of Hathaway Crossing.

Respectfully submitted.

E. W. Van C. Lucas,
Captain, Corps of Engineers.

Col. O. H. Ernst,
Corps of Engineers, U. S. A.,
President Mississippi River Commission.

FINANCIAL STATEMENT.

Appropriation for improving Mississippi River—First and second districts.

HICKMAN, KY.

July 1, 1902, balance unexpended	$876.78
June 30, 1903, amount expended during fiscal year	72.65
July 1, 1903, balance unexpended	804.13
July 1, 1903, balance available	804.13

NEW MADRID, MO.

July 1, 1902, balance unexpended	1,790.91
July 1, 1903, balance unexpended	1,790.91
July 1, 1903, balance available	1,790.91
Amount that can be profitably expended in fiscal year ending June 30, 1905	5,000.00

CARUTHERSVILLE, MO.

July 1, 1902, balance unexpended	1.43
Amount allotted from appropriation for improving Mississippi River, act approved June 13, 1902	20,000.00
	20,001.43
June 30, 1903, amount expended during fiscal year	19,613.23
July 1, 1903, balance unexpended	388.20
July 1, 1903, outstanding liabilities	388.20
Amount that can be profitably expended in fiscal year ending June 30, 1905	50,000.00

PLUM POINT REACH.

July 1, 1902, balance unexpended		691.99
Amount allotted from appropriation for improving Mississippi River, act approved June 13, 1902		105,000.00
		105,691.99
April 6, 1903, amount transferred to allotment for plant, first and second districts	$35,000.00	
June 30, 1903, amount expended during fiscal year	67,913.99	
		102,913.99
July 1, 1903, balance unexpended		2,778.00
July 1, 1903, outstanding liabilities		893.30
July 1, 1903, balance available		1,884.70
Amount that can be profitably expended in fiscal year ending June 30, 1905		120,000.00

HOPEFIELD BEND.

July 1, 1902, balance unexpended	2,307.93
July 1, 1903, balance unexpended	2,307.93
July 1, 1903, balance available	2,307.93
Amount that can be profitably expended in fiscal year ending June 30, 1905	30,000.00

MEMPHIS, TENN.

July 1, 1902, balance unexpended	$377.90
July 1, 1903, balance unexpended	377.90
July 1, 1903, balance available	377.90
Amount that can be profitably expended in fiscal year ending June 30, 1905	5,000.00

MEMPHIS, TENN. (WOLF RIVER).

Amount allotted from appropriation for improving Mississippi River, act approved June 13, 1902	10,000.00
June 30, 1903. Amount expended during fiscal year	6,272.45
July 1, 1903, balance unexpended	3,727.55
July 1, 1903, balance available	3,727.55
Amount that can be profitably expended in fiscal year ending June 30, 1905	10,000.00

HELENA, ARK.

July 1, 1902, balance unexpended	390.48
Amount allotted from appropriation for improving Mississippi River, act approved June 13, 1902	5,000.00
	5,390.48
June 30, 1903, amount expended during fiscal year	3,607.08
July 1, 1903, balance unexpended	1,783.40
July 1, 1903, outstanding liabilities	183.40
July 1, 1903, balance available	1,600.00
Amount that can be profitably expended in fiscal year ending June 30, 1905	25,000.00

DIKES.

Amount allotted from appropriation for improving Mississippi River, act approved June 13, 1902		20,000.00
April 6, 1903, amount transferred to allotment for plant, first and second districts	$4,000.00	
June 30, 1903, amount expended during fiscal year	14,885.50	
		18,885.50
July 1, 1903, balance unexpended		1,114.50
July 1, 1903, outstanding liabilities		98.07
July 1, 1903, balance available		1,016.43
Amount that can be profitably expended in fiscal year ending June 30, 1905		30,000.00

UPPER ST. FRANCIS LEVEE DISTRICT.

Amount that can be profitably expended in fiscal year ending June 30, 1905	50,000.00

LOWER ST. FRANCIS LEVEE DISTRICT.

July 1, 1902, balance unexpended	$10,073.30
Amount allotted from appropriation for improving Mississippi River, act approved June 13, 1902	125,000.00
	135,073.30
June 30, 1903, amount expended during fiscal year	81,420.78
July 1, 1903, balance unexpended	53,652.52
July 1, 1903, outstanding liabilities	53,652.52
Amount that can be profitably expended in fiscal year ending June 30, 1905	250,000.00

WHITE RIVER LEVEE DISTRICT.

July 1, 1902, balance unexpended	4,213.52
Amount allotted from appropriation for improving Mississippi River, act approved June 13, 1902	90,000.00
	94,213.52
June 30, 1903, amount expended during fiscal year	56,375.57
July 1, 1903, balance unexpended	37,837.95
July 1, 1903, outstanding liabilities	37,790.81
July 1, 1903, balance available	47.14
Amount that can be profitably expended in fiscal year ending June 30, 1905	200,000.00

UPPER YAZOO LEVEE DISPRICT.

July 1, 1902, balance unexpended	7,547.12
Amount allotted from appropriation for improving Mississippi River, act approved June 13, 1902	70,000.00
	77,547.12
June 30, 1903, amount expended during fiscal year	33,185.27
July 1, 1903, balance unexpended	44,361.85
July 1, 1903, outstanding liabilities	35,822.19
July 1, 1903, balance available	8,539.66
Amount that can be profitably expended in fiscal year ending June 30, 1905	70,000.00

REELFOOT LEVEE DISTRICT.

Amount allotted from appropriation for improving Mississippi River, act approved June 13, 1902	20,000.00
June 30, 1903, amount expended during fiscal year	18,141.29
July 1, 1903, balance unexpended	1,858.71
July 1, 1903, outstanding liabilities	1,858.71
Amount that can be profitably expended in fiscal year ending June 30, 1905	60,000.00

SURVEYS, FIRST AND SECOND DISTRICTS.

July 1, 1902, balance unexpended	$119.05
Amount allotted from appropriation for improving Mississippi River, act approved June 13, 1902	5,000.00
	5,119.05
June 30, 1903, amount expended during fiscal year	5,072.53
July 1, 1903, balance unexpended	46.52
July 1, 1903, outstanding liabilities	46.52
Amount that can be profitably expended in fiscal year ending June 30, 1905	5,000.00

PLANT, FIRST AND SECOND DISTRICTS.

July 1, 1902, balance unexpended		3,998.42
Amount allotted from appropriation for improving Mississippi River, act approved June 13, 1902		70,000.00
April 6, 1903, amount transferred from allottment for Plum Point Reach	$35,000.00	
April 6, 1903, amount transferred from allotment for dikes	4,000.00	
		39,000.00
		112,998.42
June 30, 1903, amount expended during fiscal year		86,912.64
July 1, 1903, balance unexpended		26,085.78
July 1, 1903, outstanding liabilities		19,500.00
July 1, 1903, balance available		6,585.78
Amount that can be profitably expended in fiscal year ending June 30, 1905		60,000.00

APPROPRIATION FOR REPAIRING GOVERNMENT LEVEE AT WALNUT BEND, ARK.

July 1, 1902, balance unexpended	90,000.00
June 30, 1903, amount expended during fiscal year	1,286.06
July 1, 1903, balance unexpended	88,713.94
July 1, 1903, balance available	88,713.94

MISCELLANEOUS.

February 17, 1903, amount received from B. F. Dame for rent of island in Mississippi River near Australia, Miss., for year ending February 24, 1904	1.00
February 17, 1903, amount deposited to credit Treasurer United States on account rent of island in Mississippi River near Australia, Miss., for year ending February 24, 1904	1.00

Abstract of contracts in force April 30, 1903, in the First and Second districts, improving Mississippi River.

Names of contractors.	For what work.	Rate.	Date of approval.	Date of beginning work.	Date of expiration of contract.
Hunter & Frey	Furnishing willow brush Furnishing willow poles	$1.09 per cord $2.00 per cord	(a)	Oct. 10, 1902	(b)
Anderson & Van Hook	Levee work in White River levee district, station $\frac{17}{46}$ to [illegible]	15.85 cents per cubic yard	Sept. 12, 1902	Sept. 2, 1902	Jan. 31, 1903.[c]
George R. Lacy	Levee work in White River levee district, station $\frac{37}{32}$ to [illegible]	18.95 cents per cubic yard	Aug. 28, 1902	Sept. 3, 1902	Do.[c]
Memphis Contracting Co	Levee work in Reelfoot levee district, station $\frac{0}{0}$ to $\frac{2}{24}$	12.40 cents per cubic yard	do	Oct. 6, 1902	Do.[c]
Do	Levee work in Upper Yazoo levee district, station $\frac{118}{10}$ to $\frac{120}{11}$	16.70 cents per cubic yard	do	Sept. 14, 1902	Do.[c]
Bodkin & Liston	Levee work in Lower St. Francis levee district, station $\frac{132}{0}$ to $\frac{127}{28}$.	14 cents per cubic yard	Oct. 9, 1902	Sept. 13, 1902	Do.[c]
Shutt Improvement Co	Levee work in Lower St. Francis levee district, stations $\frac{1}{0}$ to $\frac{15}{0}$; [illegible] to $\frac{21}{0}$, and [illegible] to [illegible].	15 cents per cubic yard	Oct. 4, 1902	Oct. 1, 1902	Do.[c]
Dresbach Brothers	Levee work in White River levee district, station $\frac{1}{20}$ to $\frac{3}{0}$	18.95 cents per cubic yard	(a)	Oct. 13, 1902	Do.[c]
The Stout Construction Co	Levee work in Lower St. Francis levee district, Point Pleasant, Mo.	14.45 cents per cubic yard	(a)	Nov. 15, 1902	Do.[c]
Gilchrist Brothers	Levee work in White River levee district, station $\frac{38}{0}$ to $\frac{39}{0}$	16.89 cents per cubic yard	(a)	Dec. 5, 1902	Jan. 31, 1904.
Walker Stansell	Levee work in Lower St. Francis levee district, station $\frac{127}{25}$ to $\frac{134}{0}$.	16.94 cents per cubic yard	Apr. 20, 1903	Not yet begun	Do.
M. J. Roach	Levee work in Reelfoot levee district, station $\frac{4}{0}$ to $\frac{5}{75}$	14.45 cents per cubic yard	do	Apr. 8, 1903	Do.
Do	Levee work in White River levee district, station $\frac{3}{0}$ to [illegible]	17.70 cents per cubic yard	do	Not yet begun	Do.
Geo. H. Lowrance	Levee work in Upper Yazoo levee district, station [illegible] to [illegible]	18.87 cents per cubic yard	do	do	Do.
Stout & Schmidt	Levee work in Lower St. Francis levee district, station $\frac{6}{0}$ to $\frac{8}{0}$	12.89 cents per cubic yard	do	do	Do.
Shutt Improvement Co	Levee work in Upper St. Francis levee district, station $\frac{5}{20}$ to $\frac{9}{0}$.	19½ cents per cubic yard	Apr. 25, 1903	do	Do.
Do	Levee work in Lower St. Francis levee district, station $\frac{19}{0}$ to $\frac{17}{0}$.	17 cents per cubic yard	do	do	Do.
Arnold & Co	Levee work in Lower St. Francis levee district: Station $\frac{8}{0}$ to station $\frac{14}{0}$ Station $\frac{21}{0}$ to station [illegible]	16.48 cents per cubic yard 13.98 cents per cubic yard	Apr. 27, 1903	do	Do.

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[a] Emergency contract.

[b] Work suspended on account of high water. Contract held over.

[c] Time limit waived January 15, 1903.

APPENDIX 2 A.

REPORT OF MR. AUG. J. NOLTY, ASSISTANT ENGINEER, ON CONSTRUCTION WORK IN FIRST DISTRICT, DURING SEASON OF 1902–3.

MEMPHIS, TENN., *April 30, 1903.*

CAPTAIN: I have the honor to submit this my annual report of operations of the construction parties at Island 14, Mo., Caruthersville, Mo., and on Plum Point Reach, Arkansas and Tennessee, for the season 1902–3.

Before proceeding to the report proper I wish to state that the working season covered by this was, without exception, the worst and most unsatisfactory that I have ever in my long experience on the river passed through. First of all, owing to the nonavailability of funds for repairs to the necessary plant until the beginning of the new fiscal year, no contracts for the required lumber and other material could be made until after July 1, and no lumber was received until six weeks later, hence it was the end of September before sufficient plant to justify commencement of work was ready. Scarcity of labor retarded the work greatly, there being no time during the entire season when the working parties had a full complement of men. in fact for most of the time there was but about half a force. Insufficient supply of brush also operated against us. This was partly due to the scarcity of labor and partly to the frequent submergence of the brush bars by continual oscillations in the river. This flooding of the bars left the ground in poor shape for hauling and necessitated continual moving of the brush camp in hunting for higher and dryer ground. Frequent rises in the river with accompanying run of drift was another adverse factor. At the opening of the working season the river at Cairo registered about 10 feet, the lowest reading for the season. At the close of operations it stood at 45.8 feet, the maximum, and between the time of beginning and completing work it stood for the greater part above the 25-foot mark. Running ice compelled us to shelter all plant and suspend operations for three days. Heavy storms were frequent and these, too, caused loss of time, especially for the dike party, because then it was impossible to tow out a finished section and properly align it. All these causes combined have tended to make the results of the season's work most unsatisfactory, and as the financial exhibits will show have increased the cost beyond all previous figures.

Abattis dikes (Island 14).—The project called for the construction of 2,800 linear feet of dike, this length being required to extend it across the head of a large sand bar lying between the deep water on the Missouri side and the main river channel. The location of the dike is about 3 miles above the town of Gayoso, Mo. The bar spoken of has a maximum elevation of 16.8 feet above mean low water, Cottonwood Point gauge, and the object of building the dike here, was to induce the growth of the bar landward, thus closing the chute alongshore and thereby contracting this extremely wide piece of river, the resultant of which would be scouring out of the shoal existing there.

Work was begun on December 10, the first two days being employed in loading piles furnished by contract from the bank on Island 26 onto barges. Actual work on the dike was begun on the 12th and completed to a length of 2,810 linear feet, February 25, 1903. In all its essentials the construction was similar to the dikes built in 1890–1901, and described in detail on page 246, report of the Mississippi River Commission, Chief of Engineers' Report, 1901.

The supply of brush received from the contractor was supplemented by 385 cords of brush and 267 cords of poles cut by the construction force, the contractor being unable to furnish this as required.

Periodical soundings were taken above and below the dike and plotted on the sheets herewith, but as these soundings ceased with the work, their principal value is as a basis for comparison with future surveys.

SUMMARY OF WORK.

(2,810 linear feet of dike and foot mat containing 39.9 squares.)

Field cost.

Labor, including superintendence and subsistence	$6,997.55
Brush, 441.02 cords, at $1.09 (contract)	480.71
Brush, 385 cords (hired labor)	347.28
Poles, 267 cords (hired labor)	275.22
Piling, 140 sticks, at $2 (contract)	280.00
Piling, 11 sticks (hired labor)	23.46

Stone, 696 cubic yards, at $1.64	$1,141.44
Wire, galvanized, No. 12, 4,389 pounds, at $2.68 per hundredweight	117.62
Wire, strand (old stock), 4,704 pounds, at $2.39 per hundredweight	112.42
Lumber, 83,988 feet, at $12 per M	1,007.85
Lumber, 3,000 feet, at $16.50 per M	49.50
Bolts, 800, at $4.20 per hundred	33.60
Clips, 271, at $6.75 per hundred	18.29
Washers, 200 pounds, at $4.75 per hundredweight	9.50
Coal	1,899.48
Charter of barges	525.00
Towing (pay roll)	525.93
Oils	46.12
Miscellaneous materials, etc	186.75
Total	14,077.72

Caruthersville, Mo.—The project of this place was the extension downstream of the revetment constructed in former years 500 feet, or as much as the allotment of $20,000 would permit, after raising the upper bank protection of paving all along the old work, from the 18-foot to the 27-foot contour. After the latter work was completed there remained enough funds on hand to construct an extension of standard revetment of 477 feet. The width of mat is 250 feet. Work was begun October 2 and completed November 30. The total length of revetment in front of this town is 2,342 feet.

SUMMARY OF WORK.

(One river mat, 477 by 250 feet, containing 1,192.5 squares; two connecting mats, aggregating 88.2 squares; hydraulic grading, 450 cubic yards; bank paving, 5,877.4 square yards.)

Field cost.

Labor, including superintendence and subsistence	$5,569.75
Brush, 1,600.33 cords, at $1.09	1,744.36
Poles, 69.3 cords, at $2	138.60
Stone, 4,128.6 cubic yards, at $1.49	6,151.61
Wire, galvanized, No. 12, 2,944 pounds, at $2.68 per hundredweight	78.90
Wire strand, ¼-inch, 8,056 pounds, at $4.34 per hundredweight	349.63
Wire strand, $\frac{5}{16}$-inch, 3,889 pounds, at $3.50 per hundredweight	136.11
Clips, 1,075, at $6.75 per hundred	72.56
Lumber, 5,304 feet, at $15 per M	79.56
Lumber, 2,880 feet, at $14 per M	40.32
Coal	589.25
Oils	24.82
Charter of barges	932.50
Towing (pay roll)	1,059.09
Miscellaneous	206.85
Total	17,173.91

Osceola bar, Arkansas.—In 1895 the old revetment of Osceola bar, built in 1884, was extended upstream nearly 3,800 feet. Continuous and unchecked caving above attacked this new work and gradual disintegration followed. The project for the season was the construction of about 2,000 feet of standard revetment with mats 250 feet wide, placed so that the lower terminus would overlap that part of the 1895 work still in good condition.

As above stated, the caving along the river front of this bar has been almost continuous for a number of years, until now very little is left of the at one time considerable area. In fact, at one place the caving extends back nearly to the main Arkansas shore, and the accelerated caving noted in 1901 and 1902 may have been due to the operation of the abattis dikes placed in front of Elmot bar. As early as 1896 recommendations for the revetment of this bar were made, as it was deemed important to hold the then existing shore line of an island whose growth was largely due to the closure works placed in the chute, but other work was given the preference. Until this shore line is held there can be no stability in the Plum Point crossings.

As only one mat plant was in condition for work, nothing could be done here until the mat work at Caruthersville had been completed. It was therefore

November 10 before operations were begun. Work progressed slowly on account of scarcity of brush and of labor. The river was low at commencement of the work, but was slowly rising. On December 3 there were completed of the contemplated length of the first mat 637 feet, and as the river rise had already increased since the first of the month, bringing down large quantities of heavy drift, and as reports from the upper waters indicated a further and heavy rise it was decided to sink the mat at once. During construction the bank continued caving, so much so that the abutment had to be strengthened by driving another and stronger one inside the first, and the anchorages of the mooring cables had to be moved farther inland.

Preparations for sinking were at once made, and on the evening of the 3d of December the attempt to sink was made, resulting in complete loss of the mat. This loss was due to the large accumulation of drift in front of the mooring barges, this having collected to a thickness of 15 to 18 feet, and as soon as the lowering of the head of mat was begun a slight downstream movement of the drift mass was sufficient to overturn the abutment, already weakened by the caving of the bank where the latter stood. The overturning of the abutment allowed the whole outfit to move inshore, thereby slacking some of the mooring cables and throwing additional strains upon the others, which, becoming overstrained, parted successively, while others pulled out the large trees to which they were fastened. When it is remembered that there were eight steel cables ranging in diameter from 1 inch to 1¼ inches, an idea of the great strain brought upon them may be formed. The mat floated downstream, finally lodging against the head of a middle bar below Island No. 34. The loss of this mat was altogether due to failure to obtain brush in sufficient quantities to push the work; and in making this statement it should not be inferred that the brush contractors were dilatory in their efforts to supply the work. They, too, suffered from scarcity of labor, and despite increased pay and free transportation were unable to keep more than a small force at work. The disaster to this mat was the first to occur in the first district since 1885.

The river being very high and still rising and full of drift, it was considered best not to attempt any further work here under the then existing conditions, but to move the entire plant up to Fletchers Bend.

SUMMARY OF WORK.

(One river mat, 637 by 250 feet, containing 1,692.5 squares.)

Field cost.

Labor, including superintendence and subsistence	$5,047.74
Poles, 78 cords, at $2	156.00
Brush, 2,202 cords, at $1.09	2,400.18
Stone, 575 cubic yards, at $1.64	943.00
Wire, galvanized, No. 12, 3,422 pounds, at $2.68 per hundredweight	91.71
Wire strand, ¼, 9,486 pounds, at $4.34 per hundredweight	401.69
Wire strand, 5/16, 5,131 pounds, at $3.50 per hundredweight	178.58
Wire strand, ½, 3,140 pounds, at $3.55 per hundredweight	111.47
Silicon bronze wire, 358 pounds, at 15 cents	53.70
Clips, 600, at $6.75 per hundred	40.50
Lumber, 6,000 feet, at $15 per thousand	90.00
Coal	328.00
Charter of barges	300.00
Towing (pay roll)	763.06
Miscellaneous materials, etc	162.11
Total	11,067.74

Fletchers Bend.—The project for this place was the repair of the upper part of the revetment of 1888, which, lying under a prominent salient and in a strong eddy, had suffered considerably by gradual disintegration at or near the junction of the subaqueous with the upper bank work. Some slight repairs were made in 1901, but the insufficiency of funds allotted, being only a small balance left over from the previous year, made it impossible to do anything else than to simply construct a connecting mat from 40 to 50 feet wide, which it was hoped would check the destructive work going on along the zone just mentioned. This, however, it failed to do, and after the subsidence of the flood of 1902 it was seen that the damage had become so great that at least 1,200 feet would have to be entirely reconstructed. By additional caving at the lower end this had increased by the time work was begun to about 1,400 feet.

On December 9 the mat plant was moved up to Fletchers Bend, but on account of the heavy run of drift and almost continuous rains actual construction did not begin until the 12th, upon which day the plant was swung into position for weaving. As there was still a heavy run of drift, a rapidly rising river, and very unfavorable reports from head waters, the entire plant, together with what had been woven, was swung back to bank, where it was sheltered from drift, as to continue work on the mat under existing conditions would only be inviting a second disaster. It was not until January 6 that conditions had so improved as to warrant swinging into position once more, the force in the interim being employed in unloading stone from contractors' barges, upon the bank. Hardly had work been resumed on the mat when a run of ice, lasting four days, compelled another stoppage by reason of an entire suspension of navigation for three days, this suspension preventing the towage of brush. As there was considerable mat afloat by this time the outfit could not be retired into a sheltered position, hence a drift boom of sheathed barges was placed in proper position for sheering off the ice across the mooring barges. Although the run of ice was very heavy and concentrated along the Arkansas shore, neither plant nor mat sustained the slightest damage; and this is perhaps the only instance on record where a mat outfit with attached mat has been held against a run of ice.

The brush supply, which during the entire season had been very short, was still further reduced on account of the heavy rains, making it impossible to haul over any but the highest ground of the brush bars. This made necessary the frequent moving of the brush camp, and finally, in order to complete this mat, brush had to be cut by hired labor, the carriage being as much as 800 feet from brush to barge. This mat, 771 by 250 feet, was sunk on February 2, the Cairo gauge registering 23.3 feet.

While work was going on at Osceola Bar, and after the hydraulic grader had completed grading at Caruthersville, grading of the bank to be revetted at Fletchers Bend was begun, the difficulties which afterwards retarded the progress of the work so much not then being so apparent, and it being believed that the graded bank would hold its slope until the revetment was laid. But the rising river, soon after the grading had been completed, almost entirely destroyed the slope. After the mat was sunk grading was resumed, but, the river being very high, with but poor results.

As soon as the four connecting mats, aggregating 211 squares, were laid, and a piece of bank had been graded, paving was begun; but the rapidly rising river soon stopped this work by submerging nearly all of the slope. As it was so late in the season, and as all conditions for a further prosecution of the work were most unfavorable, all work was suspended for the season on February 13.

SUMMARY OF WORK.

(One river mat, 771 by 250 feet, containing 1,927.5 squares; four connecting mats, aggregating 211.1 squares; bank paving, 1,867 square yards; hydraulic grading, 22,612 cubic yards; unloading stone, 9,776 cubic yards.)

Field cost.

Labor, including superintendence and subsistence	$14,170.68
Brush, 3,402.4 cords, at $1.09	3,708.62
Poles, 132.9 cords, at $2	265.80
Stone, 1,361 cubic yards, at $1.64	2,232.04
Wire, galvanized, No. 12, 4,776 pounds, at $2.68 per hundredweight	127.99
Wire strand, ¼, 12,484 pounds, at $4.34 per hundredweight	541.80
Wire strand, $\frac{5}{16}$, 6,456 pounds, at $3.50 per hundredweight	225.96
Wire strand, ½, 2,863 pounds, at $3.55 per hundredweight	101.64
Silicon bronze wire, 468 pounds, at 17½ cents	81.90
Clips, 614, at $6.75 per hundred	41.45
Staples, 251 pounds, at $2.90 per hundred weight	7.28
Oils	118.48
Charter of barges	400.00
Coal	2,209.96
Towing (pay roll)	1,754.88
Unloading stone (pay roll)	2,494.91
Miscellaneous	99.12
Total	28,582.51

Ashport Bend, Tenn.—A fault having developed in the revetment of 1893, the project for the season's work included the repair of this, which at the time repairs were begun had assumed the form of a deep pocket with a chord length of 280 feet. The method of repairs was the usual one, namely, to cover the bottom of the pocket with a mat well fitted into it and whose outer or river edge should well overlap the main river mat. The shape of the pocket made it necessary to make this floor mat in two sections, and the construction of the first (and lowest) one was begun on February 6 and was completed on the 10th, by which time the river was nearly bank full, the Cairo gauge registering almost 40 feet. As no more brush could be obtained, and as the season of the annual floods was drawing near, all work was suspended for the season on the following day.

SUMMARY OF WORK.

(One river mat, unfinished, 155 by 105 feet, containing 162.25 squares.)

Field cost.

Labor, including superintendence and subsistence	$536.78
Brush, 256 cords, at $1.09	279.04
Poles, 10 cords, at $2	20.00
Stone, 175 cubic yards, at $1.64	287.00
Wire, galvanized, No. 12, 445 pounds, at $2.68 per hundredweight	11.93
Wire strand, $\frac{1}{4}$, 1,186 pounds, at $4.34 per hundredweight	51.47
Wire strand, $\frac{5}{16}$, 441 pounds, at $3.50 per hundredweight	15.43
Clips, 16, at $6.75 per hundred	1.08
Oils	24.84
Charter of barges	41.50
Coal	356.00
Towing (pay roll)	350.00
Miscellaneous	16.65
Total	1,990.72

Daniels Point, Ark.—The entire reconstruction with continuous revetment of the damaged lower half of the work at this place, together with the repair of a fault at the foot of the upper (1896) revetment, was one of the projects for the season, but the same causes which so retarded the progress of the other works made it impossible to begin work here.

Field cost of work at Plum Point Reach, 1902–3.

Osceola Bar	$11,067.74
Fletchers Bend	28,582.51
Ashport Bend	1,990.72
Total	41,640.97

RECOMMENDATIONS.

Daniels Point.—I think that the lower half of the Daniels Point revetment should be repaired with standard continuous work. The holding of this bend exercises a controlling influence upon the stability of the channel down to Gold Dust, and if it becomes necessary, and I believe it soon will, to close the chute of Island 26 the holding of this bend will be all the more imperative.

Repairs to the fault in this work should be completed, and it is probable that after the recession of the high water of this year some other faults may be visible.

Fletchers Bend.—This is one of the most important works on the Reach, and its maintenance in good condition is a prime factor in preserving the good channel depths existing. During the past low water there were noted several places near the low-water line that showed plainly that some destructive agency was at work, and it is believed that work in addition to completing the repairs begun last season will become necessary. The "interrupted" revetments, too, show unmistakable signs of disintegration, but they will no doubt hold sufficiently well for another year.

Osceola Bar.—The shore line of this bend has now probably as good shape as it ever will assume. Since the construction of the Elmot system of abattis dikes the current impinges strongly against the bank, and this has caused the bend to assume a very concave shape with a correspondingly convex sand bar opposite. If neglected, it appears to me to be only a question of a very short time when Osceola Chute, and, as a natural sequence, Bullerton Chute, will be reopened.

Abattis dikes.—The closure of Forked Deer (Island 26) Chute is strongly recommended, as it is evident that the discharge through the chute is yearly increasing. A survey of this locality for the purpose of comparing it with one made several years ago would seem desirable. It is needless to point out the resultant effect of the reopening of this chute.

Gold Dust Chute should be closed by dikes branching out right and left from the head of Island 30. Both the skeleton pile dikes and the solid brush and stone dam have been tried without ultimate success, but I believe that the chute can be closed without great cost by successive abattis dikes.

The contraction of the wide reach at Island 34 by means of abattis dikes and the addition of one dike to the Elmot system are recommended.

Accompanyingi this report is a map of the vicinity of the Island No. 14 abattis dike and cross-section sheets with soundings taken above and below that dike plotted thereon.

Respectfully submitted.

A. J. NOLTY, *Assistant Engineer.*

Capt. E. W. VAN C. LUCAS,
Corps of Engineers, U. S. Army.

APPENDIX 2 B.

REPORT OF MR. W. M. REES, ASSISTANT ENGINEER, ON WORK IN THE SECOND DISTRICT, DURING SEASON 1902-3.

MEMPHIS, TENN., *May 20, 1903.*

CAPTAIN: I have the honor to submit the following report of operations in Wolf River and at Helena, Ark., for the year ending April 30, 1903.

WOLF RIVER.

It was not until late in August that the river reached a sufficiently low stage for the resumption of dredging operations. The work was begun August 26, when the stage was 10 feet, and continued until December 13, when the winter rise set in. The plant used was the dredge *Wolf* with two dump scows and a tender steamer, and the material dredged was dumped into the Mississippi River, as usual. Only a single crew was employed. There was no very low water during the season, and practically no interruption to navigation.

The stage of the river at the end of August was 11 feet. It then fell steadily until it reached a stage of 2.9 feet on September 29, which was the lowest of the season. In October the stage varied between 4 and 8 feet. Early in December a rise began, reaching 16.6 feet on the 13th, and still rising, and the season's work was then closed.

The river was easily navigable up to the railroad bridge, except for about one week, when the depth on the shoal just above the 1½ mile point was but 2½ feet, the river stage at this time being 3 feet. During the lowest stage the least depth between the mouth and the Transfer Company's incline was 4½ feet, the length of the shoal being about 300 feet, and for one week only did the transfer boat have any difficulty in carrying full loads.

The river above the railroad bridge was too low to navigate for about two weeks, but during the rest of the season boats were almost daily towing rafts, some of them going as far as the county bridge, the present head of dredging work.

Removing rock ledge.—While dredging a short distance below the Anderson-Tully mill incline, the dipper repeatedly struck some hard substance, at first supposed to be sunken logs. In attempting to remove the supposed logs, the dipper brought up pieces of ferruginous sand rock and cemented gravel. After this discovery an examination was made and it was found that a ledge of this formation covered the bed of the river from bank to bank for a length along the channel line of about 200 feet. The top of this ledge was quite irregular, with numerous hills and hollows, the former being from 1½ to 2 feet below the low-water stage.

This ledge had caused the shoal known to be at this locality for a number of years, the removal of which had been contemplated but not done, as the dredge had always been needed elsewhere.

It was decided to remove so much of the ledge as was an obstruction to navigation, and for this purpose a small scow was fitted up for a drill platform, with 3 anchor spuds, and an overhanging frame work at one end, the latter for handling and guiding the drill rods, a complete set of which belonging to a steam drill was on hand. The drilling was done by hired labor, the force consisting of 1 driller and blaster, 1 blacksmith and 4 laborers.

The method was as follows: A 3-inch wrought iron casing pipe was sunk through the sand, which generally covered the ledge from a few inches to a foot or more: the sand being washed out with a pipe nozzle supplied with water by a hand pump. A drill was then inserted and operated by the laborers with a rope passing over a sheave in a trolley block carried on the frame work above.

The holes drilled were nearly 3 inches in diameter, spaced from 6 to 8 feet apart. The depth of hole was usually the thickness of the ledge, or from 3 to 4½ feet. The charge was from 6 to 9 sticks (3 to 4½ pounds) of 60 per cent dynamite, and fired by an electric battery, one at a time. A blast generally blew out a crater-shaped hole 6 to 8 feet in diameter and 3 to 4 feet deep and shattered the material very fine, frequently into sand and gravel.

The work was begun November 17 and continued without interruption until December 13, when the rising river made the water too deep for the drill rods; 125 blasts were made and 525 pounds of dynamite exploded.

Soundings taken after the work showed the cut to be about 200 feet long, 25 to 40 feet wide, and fully 3 feet average depth. There is no doubt that the blasts have shattered the entire thickness of the ledge to the underlying gravel bed. Some of the material is still lying in the cut, and it is the intention to remove this with the dredge and to widen the cut by blasting during the next working season.

The following is a summary of dredging:

	Cubic yards.
From the mouth to the railroad incline, 0–18	8,720
From the shoal below Bayou Gayoso, 30–40	3,680
From the Cochran mill incline to old waterworks, 52–64	7,040
From the old waterworks to the hoop mill, 77–81	3,560
From the hoop mill to the railroad bridge, 85–94	7,320
From the railroad bridge to near county bridge, 99–134	11,930
Total	42,250

In addition there were removed 43 saw logs, 20 snags, 5 stumps, and 2 parts of barge hulls.

The field cost of the work was as follows:

For operating dredge:		
Labor	$2,033.33	
Fuel	621.75	
Machinery repairs, including new chains	519.91	
Oils and engineer's supplies	85.25	
Ice	9.10	
		$3,269.34
For operating tender boat:		
Labor	1,159.50	
Fuel	410.75	
Oils and engineer's supplies	18.00	
Ice	9.10	
		1,597.35
Total field cost for dredging		4,866.69

Cost per cubic yard for dredging, 11.52 cents.

The total expenditures from May 1, 1902, to April 30, 1903, were as follows:

For operating dredge and tender, as above	$4,866.69
For blasting rock ledge	570.18
For repairs to floating plant	492.75
For property purchased	130.35
For Memphis office expenses	212.50
Total	6,272.47

Cost per cubic yard, on basis of total expenditures, 14.85 cents.

HELENA, ARK.

The bank protection work at this locality consists of 1,140 linear feet of continuous mattress revetment, with stone paving up to the 23-foot stage, built in 1889 and 1899, followed on the downstream end by a system of four main dikes built in 1889, and two intermediate dikes built in 1898, thus protecting 1,180 linear feet of the bank. The intervals between the dikes, except the lower one, have mattress revetment extending to slightly above the low-water stage, but the bank above these is not revetted. Below the dikes is 2,580 linear feet of continuous revetment, built in 1896 and 1898, and consisting of fascine mattresses and stone paving extending to the 25-foot, and in some places to a higher, stage. The total length of the protection work is 4,900 feet.

The levee protecting the city is close to the top of the bank along nearly all of the revetment. At the dikes it approaches to within 30 feet, and below the dikes it is so close that for nearly 1,000 feet the toe of levee and top of bank practically coincide.

For several years prior to 1901 there was a slight settling of the revetted bank; this increased considerably during the low water of that year, and remained in about the same condition after the low stage of 1902. The extent of the settling is about as follows: Between dikes 1 and 3 a series of pocket caves have occurred, four in all, situated between the dikes where the bank was not revetted, and involving only the portion of the bank above low water, there being no disturbance to the mattress revetment below. Two of the pockets are over 75 feet long, 30 feet wide in the middle, and the earth has dropped vertically fully 10 feet.

Much seep water was discharged from the bank at these caves, making the material there quite soft, and obviously this has been the cause of the caving, the earth becoming so saturated that it sloughed.

From just below dike 4 to below dike 6, a distance of about 1,600 feet, there is almost continuous settling, indicated by a crack which extends persistently along the bank at about the 25-foot contour line on the Helena gauge. This is at about the top of the paving, and where this extends higher the crack goes through it.

The amount of settling is from a little to fully 5 feet. About 200 feet below dike 4 it is 4 feet; at the box-factory incline, 1 foot; 100 feet below this it is 4 feet; at McCoy's incline and thence to the head of dike 5½ it is 3 feet; then it is small for some distance, when it again increases and is over 5 feet at dike 6. The settling is greatest at the crack and decreases rapidly down the paved bank, the bank at the low-water line and for some distance above being undisturbed. Thus at McCoy's incline the settling just below the crack was 3 feet; 12 feet below, 2 feet; 24 feet below, 1 foot; and at 36 feet below it was zero. Water was seeping from the bank at a number of places, the greatest quantity from just above the box factory.

The character of the settling, the fact that the bank below low water is undisturbed, and the flow of seep water indicate that the latter is the cause of the trouble, and that if this can be drained out further settling will be prevented.

The project for the work was to cut into the bank a series of lateral drain ditches and fill them with brush in the bottom and riprap stone above, the ditches to start near low water and have a rather flat grade back to the fault line.

Work was begun November 13 and continued until December 3, when it was suspended on account of too high water. During this period all excavation was done. Nine ditches were begun, but only four were completed, and these to the 7 and 8 foot stage only, this being as low as they could be cut. In constructing the ditches an open cut was first made, usually 6 feet deep and 6 to 7 feet wide on the bottom, after which the excavation was continued with sheet piling, the sides being narrowed in to a bottom width of 3 to 4 feet. The sheathing was used only in the 4 completed ditches.

Work was not again resumed until early in February, 1903, and then the only work done was to finish filling the ditches with stone.

The work done was: Three ditches cut in dike pockets, each 3 feet wide at bottom, 3½ feet deep, and aggregating 240 linear feet. They curve along sides of pockets, with bottoms at 10-foot stage, increasing to 20-foot stage inland. All were incomplete.

Ditch No. 1, 100 feet above box-factory incline, 78 feet long, 14 feet maximum depth, bottom at 8-foot stage.

Ditch No. 2, 40 feet above box-factory incline, 32 feet long, 3 feet deep; unfinished.

Ditch No. 3, 20 feet below box-factory incline, 40 feet long, 6 feet maximum depth, bottom at 16-foot stage; unfinished.

Ditch No. 4, 120 feet below box-factory incline, 52 feet long, 14 feet maximum depth, bottom at 8-foot stage.

Ditch No. 5, 230 feet below box-factory incline, 50 feet long, 14 feet maximum depth, bottom at 8-foot stage.

Ditch No. 6, 80 feet below McCoy's incline, 86 feet long, 15 feet maximum depth, bottom at 7-foot stage.

About 20 cords of brush and 480 cubic yards of stone were used in filling ditches, and 481.64 cubic yards of stone stored on the bank for future use.

The total expenditure was $3,919.40, including $303.89 Memphis office charges, and stone valued at $963.28 stored on the bank.

Respectfully submitted.

W. M. Rees,
Assistant Engineer.

Capt. E. W. Van C. Lucas,
Corps of Engineers, U. S. Army.

Appendix 2 C.

REPORT OF MR. AUG. J. NOLTY, ASSISTANT ENGINEER, ON CARE OF AND REPAIRS TO PLANT FOR YEAR ENDING APRIL 30, 1903.

Memphis, Tenn., *May 13, 1903.*

Captain: I have the honor to submit my annual report of operations of the "Care of and repairs to plant" party for the year ending April 30, 1903.

Dredge Wolf.—The repairs to this machine were paid for out of balance available from the allotment for dredging Wolf River. The machine was docked and had its hull repaired by cutting out decayed timber and replacing with sound; the hull was calked all around, had two new side spuds put up, new spud guides on each side, new timber foundation for shears and boom seat, new heavy iron dipper bails made, machinery overhauled, and had the outboard half of the boom entirely renewed. This latter work was rendered necessary by the warping of the timber out of which the boom was lengthened the previous year, it being so badly twisted and warped that it could no longer be worked in that shape.

Dump scows.—The repairs to these (2), which consisted in calking and resheathing the bins, were paid for same as the dredge *Wolf.*

Steamer Graham.—The old cabin of this vessel, built in 1879, could no longer be kept in repair, hence an entirely new one was built. The original structure being a very unsightly one some alterations, tending to make the boat look neater and to insure more comfort to the crew, were made in erecting the new cabin. The boat also received two new stacks, new breeching, repairs to boilers and feed-water heaters, and had machinery thoroughly overhauled. This vessel should be docked this season in order to have hull repaired. It will then be in very good condition, and should remain so for at least five years.

Steamer H. L. Abbot.—Was docked, and had hull, which was in extremely bad condition, rebuilt, cabin repaired, and engines and machinery overhauled. Present condition very good.

Steamer Chisca.—Was painted inside and out, had roof repaired, engines and other machinery overhauled, and received minor repairs to hull. This vessel will be taken on the ways this season for repairs to hull, our floating dock being too small to hold this boat.

Steamer Titan.—This boat has been laid up since 1900, and her general condition is poor. Our dock being too yielding to straighten this boat properly, it will be taken out on the ways at Paducah, Ky.

Steamer Itasca.—Received two new pitmen and received repairs to engines, furnace, and cabin. Present condition good.

Pile driver 6.—This machine belongs to the works above Cairo and was loaned to this work three years ago. It being in an entirely unseaworthy condition, it became necessary to dock it and rebuild the hull. It also received repairs to machinery and cabin. Present condition good.

Pile driver 9.—This also was loaned to this work from the works above Cairo. It received only such repairs as would make it safe for the season's work. It will be docked this season and receive repairs similar to No. 6. Present condition poor.

Shop boat.—Had hull calked while afloat, guards repaired, roof repaired, new timber heads put up, and shafting relined. Present condition fair. Should be docked next season.

Hydraulic grader 2.—Received minor repairs to hull and machinery. Present condition good, but should be docked for repairs to hull next season.

Quarterboats Amelia, Mississippi, and No. 12.—Received repairs to hull without docking, and to cabins. The latter were painted inside and out with cold-water paint applied by a MacLeod spraying machine. All three should be docked within the year.

Quarterboat 25.—Was docked and had hull thoroughly repaired; also received repairs to cabin. It was painted inside and out with cold-water paint applied by spraying machine. Present condition good.

Quarterboat 11.—Docked and hull entirely rebuilt; also cabin and guards repaired. This boat is now practically as good as new.

Quarterboat 221.—Docked and hull entirely rebuilt. Cabin repaired and guards widened. This is one of the two-story quarterboats, and it is now as good as new. The cabin will be painted inside and out.

Quarterboat 206.—This is a sister boat to 221, and is receiving the same repairs as the other and will then be in equally as good condition.

Quarterboat 39.—This is the survey party boat. It was docked and had hull rebuilt and cabin repaired. It will be painted inside and out. Present condition very good.

Floating dock.—Received new end gates, new foundation blocks, and had sides repaired and calked. It is in fair condition for docking all pieces except the steamers *Chisca* and *Titan*, it being so much weakened by age that it will no longer straighten a stiff vessel of their kind.

Barges.—Nos. 9306, 9329, 9321, 9324, 9326, 9310, 9304, all built in 1893, and Nos. 9407 and 9408, the latter two being models built in 1894, have been entirely rebuilt, and are practically as good as new.

Barge 9322.—Rebuilt in 1898, received an entirely new deck, including a full set of deck beams. Present condition fair.

Mattress barges 5 and 6.—Two mattress barges, built in 1893 at Elizabeth, Pa., and which were in such a condition as to render them entirely unseaworthy, were cut down to a length of 145 feet, their original length being 160 feet, and were completely rebuilt, making them practically as good as new. Two other mattress barges, now unseaworthy, have been beached and are being stripped preparatory to being rebuilt.

Flats.—Two new 50-foot flats have been built to replace two in such condition as to make them unworthy of repair.

Barges 9328 and 9405 have been beached and are being stripped ready for rebuilding. Mattress barges 9312 and 9308 have been beached and are being stripped for rebuilding. Barge 9402 was beached, blocked up, and stripped preparatory to being rebuilt. Before any new work could be done the high water of 1903 lifted it off the blocks, and the barge will have to be again jacked up. Four dike, 2 mooring, 2 fascine, and 12 other barges received temporary repairs sufficient to make them seaworthy for the past season's work.

A considerable amount of necessary repairs to tools and appliances and to floating plant not required on construction work during the past season was done. Condemned grader 40, and condemned pile drivers 19 and 20 have all had the machinery removed from aboard. This will be used on the proposed grader and pile driver combined which is to be built this year.

Three different kinds of wood preservative have been applied to all new timbers used in the foregoing repairs, viz, carbolineum avenarium, royal preservative, and spirittine, the prices per gallon being, respectively, $1, 65 cents, and 25 cents. The former and highest priced preparation was used on all steamboat and model barge work, and the two last-mentioned ones on all square barge work.

All floating plant, the condition of which is not specifically mentioned above, is in very bad condition, and unless rebuilt at an early day will hardly be worthy of repair.

The increased cost of repairs is mainly due to the steady advance in the price of lumber.

The following is a detailed statement of expenditures on account of care of and repairs to plant for the period covered by this report:

Care of plant	$12,794.96
Superintendence	1,250.00
Dredge *Wolf*	1,450.70
Dump scows	298.99
Steamer *Graham*	4,171.52
Steamer *Abbot*	2,179.28

Steamer *Chisca*	$1,791.37
Steamer *Itasca*	666.47
Pile driver 9	49.44
Pile driver 6	712.69
Machine shop boat	461.19
Hydraulic grader 2	190.62
Quarterboat *Amelia*	265.46
Quarterboat *Mississippi*	319.97
Quarterboat 12	207.76
Quarterboat 25	2,107.73
Quarterboat 11	2,981.12
Quarterboat 221	2,000.93
Quarterboat 206	2,100.00
Quarterboat 39	1,274.86
Barge 9306	2,284.60
Barge 9329	2,112.62
Barge 9321	2,414.98
Barge 9324	2,077.30
Barge 9326	2,094.26
Barge 9310	2,089.55
Barge 9304	1,596.55
Barge 9322	942.93
Mattress barge 5	3,064.39
Mattress barge 6	3,089.42
Model barge 9407	3,083.14
Model barge 9408	3,298.38
Floating dock	540.80
Flat 1	396.01
Flat 2	401.17
Purchase of tools, appliances, etc	874.02
Repairs to tools and appliances	665.69
Barge 9402	549.13
Skiffs and flats	33.50
Model barges	142.81
Quarterboats	209.35
Mattress barges	256.19
Barges	3,556.50
Mooring barges	69.38
General repairs to plant	2,154.45
Towing	3,443.33
Total	78,715.51

Respectfully submitted.

AUG. J. NOLTY,
Assistant Engineer.

Capt. E. W. VAN C. LUCAS,
Corp of Engineers, U. S. Army.

APPENDIX 2 D.

REPORT OF ASSISTANT ENGINEER A. J. NOLTY ON OPERATIONS DURING FLOOD OF 1903.

MEMPHIS, TENN., *April 20, 1903.*

SIR: I have the honor to submit my report of operations during the flood of 1903 upon the levee from Point Pleasant, Mo., to Pecan Point, Ark., a distance of 110 miles.

Pursuant to verbal instructions received from you on March 8, I left Memphis on the evening of that day aboard the steamer *Chisca*, taking along a good supply of bags, shovels, wheelbarrows, and other material necessary for a high-water fight. Your instructions were for me to take charge of this 110 miles of levee and to prevent, if possible, any break in the line. In this duty I was to be assisted by Inspectors Mosby, in charge of miles 0 to 22; Markey, miles 22 to 40; Kilpatrick, in local charge of the work on the Caruthersville loop; Gowen, in charge of miles 40 to 60; Wiggs, from 60 to 90; and Wigstrand, from 90 to 110. These inspectors had under their orders from one to three subinspectors each.

On my initial trip I made it my business to become acquainted with the inspectors and their subordinates and to receive reports on the condition of the sections in their charge, reserving for a subsequent trip actual inspection by myself. For a better understanding of this report it will treat of the various sections in geographical sequence, beginning with the first or up-river one. Caruthersville loop will be treated separately, as the work there was not maintenance or repair, but rather new work.

Mile 0 to mile 22.—Inspector W. L. Mosby in local charge.

From 0 to milepost 3 the crown of levee was about 3.5 feet above the highest stage of water attained during the flood, and no work of any kind was required.

From milepost 3 to 8 there was a safe margin of 2.5 feet above the highest stage, and no work was required.

Milepost 8 to 11, the height of crown above water was 2 feet, with the exception of about 100 feet, 8/3 to 8/4, where the levee had been cut and not restored to proper height; 2.5 feet of topping was required here to prevent running over.

Milepost 11 to 13, there was a safe margin of 1.5 feet, except for 200 feet, 12/43 to 12/45, where the crown of levee had been used as a horse and hog corral and worn down so that an average of 1 foot of topping was required.

Milepost 13 to 15/20, the crown was 0.8 foot above flood stage, and as the levee was in good condition no work was required here.

From 15/20 to 16 the elevation of levee above highest water was 2.5 feet, and no work was required except upon a spur at 15/42, where some sack revetment had to be placed to prevent cutting away of this spur.

Milepost 16 to 21, the crown was nearly 4 feet above the highest stage, and the only work required on this 5 miles was upon a spur at 16/12 which had to be treated similarly to the one at 15/42. The last mile of this division had a margin of 2 feet and no work was required. It will be seen that on the whole this section of levee is in good condition, and furthermore that the bulk of the work done here was due to unauthorized tampering with the levee. The pay roll during the high-water fight was $274.71, which includes the pay of the inspector for twenty days.

Miles 22 to 40.—Inspector S. S. Markey in charge.

The general condition of this section is good except as to sod, which is poor from milepost 30 to milepost 40, the Bermuda having been killed by the rank growth of weeds. However, as most of this 10 miles lies along the chute of island 16, which is very narrow, and the levee is therefore protected by the island, there was but little damage from wave wash. There was very little seepage, except at 38/20 to 38/30, where it was necessary to do some revetting to counteract the effects of seepage. The pay roll for this section, inclusive of twenty days' salary of the inspector, was $230.76.

Caruthersville loop.—The advent of the flood of 1903 found a long gap in the 2-mile loop below the town of Caruthersville, while the front line was threatened by the caving of the bank. The delay in closing the gap in the new line was primarily due to delay in securing the right of way by the local levee board. This matter was not settled until the 6th of February. The contractors at once began the work of closure, but owing to heavy rains the dirt was in bad shape for handling. Continued heavy rains aggravated matters until the contractors suspended operations on the plea that it was impossible to move the material. The situation, then, in view of the rapidly rising river, became extremely critical, and was about as follows: On the main loop there was an unfinished gap of about 1,200 feet, most of it only from 1 to 2 feet above the surface of the ground. The bank in front of the old line had been and was still caving, so that at two places the base of levee was about to be attacked. Should this front line give way, there was nothing to prevent the water from pouring through the unfinished gap and thus flooding the country behind. This would have been destructive not only to a large area of thickly settled and well-tilled farming land, but also to the large interests in the shape of mills, logs, and finished products of the Chicago Mill and Lumber Company. All the land inclosed by the front line and the new loop, as well as that in rear and adjacent to the latter, was under water from the heavy rains, augmented later by seepage through the front levee, so that only isolated patches of the more elevated portions of the ground were visible. This condition of affairs of course precluded the use of scrapers and teams, hence the only way of moving the dirt was by means of wheelbarrows. As it was important to hold the front line at least long enough to bring the work in the gap up to a safe elevation, the maintenance of the front line was assigned to the local levee board, to be assisted by the United States force when necessary, while to the latter was assigned the duty of closing the gap. In this work we were materially assisted by the Chicago Mill and Lumber Company, who shunned no expense and whose officials on the ground worked hard and efficiently and in perfect harmony with our force. Two large quarter boats, capable of subsisting 250 laborers, were stationed close to the work, and the force was kept at a maximum as long as necessary.

As it was feared that the front line would cave in before the work on the rear line was sufficiently advanced, a short loop behind the old levee was hurriedly built behind the location of the most active attack of the river. In this work the Missouri board was assisted to the extent of ninety days' labor by the United States force. Earth for this emergency loop was mainly taken from the front line, which would have soon caved in. For the work on the main loop all material had to be wheeled to place, the length of wheel exceeding 600 feet at two places and being nowhere less than 300 feet. To facilitate matters a plank haul way about 1,100 feet long was built from near the levee to an area of high ground. Teams were then employed to haul this dirt, dumping it near the levee, from whence it was wheeled to place. Later the Chicago Mill and Lumber Company obtained some light rail and 12 dump cars. The track was laid along the berm below the gap, rising from thence to the top of levee and crossing the gap on short trestles. This method was an improvement over that of transportation by barrows, but was begun too late to have much effect in reducing the cost of moving material.

In building up the gap two drainage ditches, properly revetted to prevent enlargement, were left open to the last to permit the outflow of rain and seepage water. In addition to these ditches, the Chicago Mill and Lumber Company installed a pumping plant consisting of one 8-inch Cameron mining pump, which discharged the water across the levee without, however, having much effect in reducing its height. They therefore obtained an 8-inch centrifugal pump, together with proper motive power, and had this almost in running order when the necessity for any further work ceased by reason of the decline in the river.

During the entire fight both here and at other places the weather was most favorable for work and for the preservation of the levee, there being very little precipitation, and, with the exception of one day, not enough wind to cause anxiety.

Work was begun on this loop with a small force on March 7, the tow of quarter boats having left Memphis on the 4th. The force of laborers was rapidly increased to 250 men and kept at that number up to the 28th, when it was reduced to 30 men, who were retained for two days longer for the purpose of moving out all machinery, tools, and materials, and loading same upon barges for transportation to Memphis.

The total amount of earth placed in the gap was 6,535 cubic yards; cost of labor, subsistence, and team hire, exclusive of $171 expended on front line, $8,482.74; cost per cubic yard of material moved, $1.30. The Chicago Mill and Lumber Company expended on their own account the sum of $5,000. Labor was paid 15 cents per hour for week days and 22½ cents per hour for Sundays, with subsistence in both cases. As this work was urgent men were worked ten hours each day, Sundays included.

Assistant Engineer A. F. Kilpatrick was in local charge, and was ably assisted by Overseer C. W. Fink.

Miles 40 to 60.—Inspector W. H. Gowen in charge.

This 20 miles of levee is in good shape as a whole, having an ample cross section and safe height, with the exception of mile 51 to 51/43, which is to be enlarged this season. As will be seen, considerable work was required, but none of this was due to any deficiency in the construction. The necessity for the work was due either to saturation, to wave wash, or to the almost criminal carelessness of the very people who should have the greatest interest in the preservation of the levee. With the exception of miles 45 to 47 the section had a safe margin of from 2.5 to 3.5 feet. Along the 3 miles excepted the crown was somewhat worn down by continued use of the levee as a roadway. It appears that in Missouri no regard is paid to stock laws, and hogs and cattle are allowed to roam at will, much to the injury of the work. They also, in this State, ride or drive upon the levee at will, and as none of the United States employees have police powers there is no way to enforce a request to put up stock or to refrain from driving upon the levee.

Mile 40/5 to 40/6, levee sloughed some and had one boil. Repaired with plank and sacks and boil hooped.

41/17, small cave on river side repaired with sacks.

43/45 to 43/47, levee sloughed some; repaired with revetment of brush and sacks.

46/41 to 47/3, river slope revetted with sacks to prevent wave wash.

47/3 to 47/5, sloughing checked and one boil hooped.

48/30, the levee here crosses a slough and a very bad boil developed here. This was properly repaired. There should be built here, as well as at other places where the levee crosses a slough or low ground, a good banquette.

48/45 to 48/47, sloughing; repaired with fence rails weighted with sacks. Should be a banquette here.

48/44, boil checked by building hoop.

51/32 to 51/35, revetted slope to prevent wave wash; checked two boils by means of hoops.

52/43 to 52/44, boils and sloughing checked in the usual manner.

54/46 to 54/47, sloughing checked with brush weighted with sacks.

56/8 to 56/11, sloughing checked with brush and sack revetment.

56/11 to milepost 60, levee in good shape and no work required.

Between miles 40 and 41 an 1897 crevasse was closed, and this crevasse left a deep pool in rear. This seeped badly and a banquette should be added here. At 40/7 a milk or dairy house was dug into the river side slope which caused bad boils on the opposite side. The house should be removed and hole filled up. At 41/17 a gin is built on land side of levee, which latter is badly undermined by rats. There is also a platform scale set in the crown of the levee; this should be removed.

Between miles 44 and 45 the slope on land side is badly worn away by too close driving. Driving is also done on top of levee, which is in consequence cut and worn badly.

Between miles 51 and 52 the levee was found badly torn up by the rooting of hogs. Some enlargement may be required here.

At mile 55 the levee crosses River Styx, and a banquette should be added to this part.

At miles 56 to 57 the driving is too close to levee and hence the foot of slope is badly cut up. At Barfield crossing a banquette is badly needed across the slough.

The total amount of pay roll properly chargeable to high-water fight for this 20 miles of levee was $841.66.

Miles 60 to 90.—Inspector H. Wiggs in charge.

Mile 60 to 65/30, the levee was found in good condition, being from 2.5 to 4 feet above the flood stage.

Mile 65–30, this being the end of the 1901 enlargement, to mile 67; it was necessary to put up topping about 1 foot high. As the levee was of buckshot, but few sacks were used. A few sipes had to be treated in the usual manner.

Miles 68 and 69 were about 2 feet above high water 1903, and beyond correcting a few sipes nothing was required.

At milepost 69 a spur had been built to deflect the current around a sharp angle, and here it was necessary to top this spur with sacks to prevent erosion. This spur should be raised to the same grade as the levee proper.

Mile 70 to 71. This stretch is badly rooted up by hogs. Beyond this it is in good shape and developed no weakness.

Mile 71 to 72. In good condition and very little work required.

Miles 72, 73, and 74. Owing to low grade, it was necessary to top most of this mileage with from one to two sacks high. Some sipes and small sloughs were treated.

Mile 74. The town of Luxora is located here, and one of the hardest fights of the flood was made. Nearly the whole of the business portion of the town lies outside of the main levee, and some years ago the citizens built a small protection levee around this part. The main levee, where it runs through town, is a high one, while the protection levee, originally much lower than the former, was much worn down by reason of having been used as a driveway, so that it could hold only a moderately high flood. Instead of raising this short levee, which could have been quickly and cheaply done, about the only thing the citizens did was to look idly on and make wagers as to the probable date when the flood would overtop it. As before stated, the main levee was high, and in order to decrease the grade it had been cut down deeply where it crossed the main street, as well as at a road crossing one-half mile lower down. No attention was paid by the town to the street crossing until the flood had overtopped the protection levee and stood against the main one. It was then seen that something had to be done at once if the water was to be kept out of the residence portion of the town. It had been assumed that the citizens or the town authorities would protect and care for that part of the levee which protected their property, hence not much attention was paid by us to this part. Even after the water stood against the main levee and nearly flush with the top of the cut they treated the matter lightly and assured me that they would take care of it and that they had collected sufficient money to do the work. It afterwards turned out that they had collected the munificent sum of $43.50 for this work. The first difficulty that confronted them was the matter of obtaining dirt for the closure. On the upper side of the street the buildings stood close against the base of the levee and nothing could be taken away there. On the opposite side there was a vacant lot between the levee and the first house, but the lady owning both the vacant lot and the house refused permission to take dirt away. They then took the material from what was left of the ramp, and this not being sufficient, they robbed the land side of levee, using plows and scrapers. The day after they began work I was there and saw that they had robbed so close that the mules were beginning to mire. Seeing that if this work was continued longer in this way a crevasse would result, the inspector in charge ordered them to stop.

The situation now had become extremely critical, and, as the citizens confessed their inability to proceed further unaided, I assumed charge of the work, placing Inspector Wiggs in local charge. The lady owning the vacant lot, now realizing the danger to which her property was exposed, was easily prevailed upon to allow dirt to be taken from her lot. As much of the surface was covered with sipe water, dirt was also obtained by cutting down the sidewalks adjacent to the levee. By this time the latter had become very soft and was sloughing badly, besides being threatened with overtopping, and for a time a successful termination of the fight waged looked extremely doubtful. All available men were put to work and kept at it day and night until all danger was past. The method of backing up this piece of levee was by first laying a 6-inch mat of hay over the entire surface involved, hay being used as no brush was obtainable within economical carrying distance; then placing 1 by 6 inch lumber about 10 inches apart upon the hay, and then loading this with filled sacks. With the exception of a small section on the river side the levee was practically built up of filled sacks.

At the same time that work was going on at the street crossing another very bad slough developed at the neglected road crossing about one-half mile lower down, and this at one time threatened to become more menacing than the former. Prompt work checked the danger, but both this and the upper crossing had to be carefully watched until the river had fallen several feet.

In addition to the work just described, the entire levee from Luxora to near the town of Osceola required topping, most of which was of sacks. To give some idea of the magnitude of the work required at Luxora it may be stated that 8,000 sacks were used in the immediate vicinity of that town, most of these on the two crossings.

Before leaving the subject of the flood fight at Luxora I wish to recommend the devotion to duty and the untiring energy of Inspector Wiggs. I am the more prompted to do this as reports were at the time circulated by stay-at-home flood fighters that Mr. Wiggs was entirely incapacitated for the performance of his duties by reason of habitual intoxication. During the critical period of the fight at this place rarely twenty-four consecutive hours passed that I did not stop and go ashore at Luxora, and I never, either day or night, failed to find Mr. Wiggs on the levee, and this despite the fact that his physical condition was such as to render occasional absence from duty excusable. There was at no time, either here or at Osceola, a scarcity of critics, alarmists, or would-be newspaper correspondents who found fault with the methods of doing the work, or who constantly magnified the threatened danger, or who would claim entire credit for the successful termination of the fight.

Miles 74 to 79. In addition to the work just described, nearly the entire distance between Luxora and Osceola required topping with sacks. Several bad sipes and sloughs had to be treated, notably one of the latter at Lynchs Bayou, about mile 77. Here the levee crosses what was once a deep bayou, and toward the end of the flood season the land side began to slough badly. This was properly treated with sacks, brush, and some lumber, and required constant watching until the subsidence of the flood. A good banquette should be constructed here.

Osceola, Ark. Formerly the levee ran through the center of the town, or through what is now called "old town." Some years ago the town received permission from the levee board to remove that part of the main levee running through and to use the material in raising and enlarging the small protection levee that the town had built to protect that territory lying outside the main levee. The town authorities agreed to take charge of this levee during the flood, and, as it was a high and strong levee, having everywhere a safe margin of at least 2 feet, no attention was paid to it by our employees. Later on, however, several representative citizens of the town waited upon me and requested me to include their section of levee in that under our charge, they stating that there was considerable dissension among themselves as to where or how work should be done. Knowing that their levee was at no point threatened, either by overtopping, sloughing, or other causes, I did not pay much attention to this request, except to simply request Mr. Wiggs to have it inspected occasionally.

From Osceola to Sans Souci considerable work was required both in topping low levee and in treating sloughs and sipes. Three bad sloughs between Drivers and Sans Souci required considerable work and about 2,000 sacks. Numerous sipes were found, but none dangerous. In addition, the levee was pretty well honeycombed with mole burrows, but these, being always near the top, required nothing more than close watching.

Below Sans Souci the levee for about 1 mile fronted an open foreshore, and protection against wave wash was the only thing required. From here to Butlers, the lower terminus of this division, the only work required was the treatment of some bad sipes just above the last-named place.

It will be seen from the above that the levee on this 30-mile division is on the whole a good one, and that by far the largest part of the work required was on the 5 miles in the vicinity of Luxora—that is, for 1 mile above and 4 below. The pay roll for this division was $3,548.

Miles 90 to 110.—Inspector Fred Wigstrand in charge.

From 90 to 94 the levee is in good shape and no work was required.

Miles 94 to 101. In this section there were treated a few sloughs, none of them serious except at mile 98, where hard work was required to prevent a washout at the place where the levee has a sharp salient. Before this was made secure with a sack revetment on the river side, nearly one-half the cross section of the levee had been destroyed.

Miles 102 to 103. Several sloughs had to be revetted with sacks laid upon a mat of cotton stalks, the latter being the only material available and answering its purpose very well.

Mile 104. The first 2,000 feet of this mile is good levee, but the balance is poor, having narrow crown and very steep slopes; some topping had to be done and several sloughs checked.

Miles 105 to 108. All this section is poor levee, having narrow crown and steep slopes, the latter being about one on two. It is also for nearly its entire length exposed to wave wash, having an unprotected foreshore. Much topping was required, and several very bad sloughs required extensive treatment.

Miles 108 to 109. At mile 108 the Random Shot crevasse occurred. This was about as poor a piece of levee as could be constructed with the expectation of holding back a flood. It was low, had a very narrow crown, and slopes of not more than one on two. Its height is about 10 feet. The material of which it is built is good, being tough buckshot; but having so small a cross section, even this material became saturated in a short time after the water came against it. Topping, some of sacks and some of earth thrown up, was required for the entire mile. It was plainly evident that the 2 miles between 108 and 110 were the worst of this division, and that it would require hard work to hold it. On March 19, at 3 p. m., the levee broke at mile 108. A storm prevailed at the time, the wind being partially on shore and strong enough to cause high waves, which broke over the levee. One of our foremen who was walking toward the break and who was close to it when it occurred said that the levee was pushed out bodily for about 40 feet, and that it looked to him like the two wings of a double door opening upon its hinges. I arrived at the break on the following morning and estimated its width then at 300 feet. Its ultimate width at the end of the flood was 550 feet. It probably was fortunate for Pecan Point that a crevasse occurred here, as it relieved the pressure against that levee, which was even in worse condition than that which broke.

Miles 109 to 110 (Pecan Point).—This is not only a poorly built piece of levee, but one very badly located, crossing, as it does, Barney Bayou at three places within a short distance. Where it runs through the best part of the town it is very low, hardly deserving the name of levee. It required the constant attention of the inspector and almost continuous work of his large force to hold it. All the bayou crossings sloughed badly, and long revetments of sacks placed upon mats of cotton stalks and lumber were required. Almost the entire section had to be topped with from one to four sacks high.

The amount of pay roll chargeable to this 20 miles was $2,923.62.

While it would have been very gratifying to have escaped without any crevasse during the flood of 1903, a very good showing is made when comparisons between the disasters during the 1897 flood and the one just past are made. In the former year there were 22 distinct breaks in the total mileage of levee covered by the above report, while during the late flood, with the flood stage higher than ever before, there was only 1.

I think that the levee from milepost 94 to 110 should be enlarged as recommended in the report of Inspector Wigstrand, which is submitted herewith, and that banquettes should be added, not only as recommended by Mr. Wigstrand, but also at such places mentioned by me as necessary at other places.

The river was at or above the danger line at Memphis for thirty-eight days, but the duration of the flood which endangered the safety of the levee may be taken at twenty days. Had the stage increased but 6 inches more, or had it not fallen as rapidly as it did, there is no doubt but what we would have been less fortunate, for much of the levee was taxed to its utmost at the time when the strain against it was relieved. Escape from more than one break was also largely due to the very favorable weather that prevailed during the entire period of the fight, there being very little rain and but two heavy wind storms, neither of long duration.

Much credit for the successful termination of the flood fight is due to the efficiency and untiring energy of the various inspectors and their subordinates. All performed their duties in such a manner that no fault could be found with them.

To the cost as given above should be added $782.58, expenses of the steamer *Graham*, which brings the total of pay rolls, team hire, and subsistence to $17,259.87.

During the flood the lack of systematic organization and conduct of operations made itself keenly felt. More especially was this lack of system apparent on the lower 50 miles of the levee under my charge; and although toward the end of the fight some improvement had been made in the conduct of affairs, there was room for further improvement, which, however, could not be inaugurated on account of the short space of time within which to do this. On the upper 60 miles—that is, from Barfield up—operations were well and economically conducted, for which there are three reasons: First, there were here three resident inspectors who had been on the levee a long time, and each one was thoroughly familiar with the condition of his section of levee, and therefore they knew just where the weak places were; secondly, this 60 miles was a better built levee, and hence required comparatively little work during the flood; and, thirdly and probably the most important, there was no divided authority here, this mileage being under the sole control of United States employees. All the work done was well done, and I believe that the result of the fight was satisfactory, as far as the maintenance of the levee was concerned, but I firmly believe that with a better system the same results would have been obtained at much less cost to the United States. I therefore take the liberty to offer such suggestions as have presented themselves to me during the late flood operations.

First. The United States should, in time of flood, assume sole control of all levees built or enlarged by it and also of such levees built by levee boards whose maintenance is essential to the stability of the former.

Second. Foremen, timekeepers, and principal guards should not be taken from resident planters or merchants, but should, if possible, be brought from some of the larger cities. In fact, the best and most economical plan would be to have quarter boats or camps located at points determined with reference to the probable amount of work required; these men to be subsisted and to be recruited the same as the construction forces now are. Where natives are employed as foremen, timekeepers, or in other responsible positions where they have the authority to employ others, they are apt to employ every man whom they know, and thus they are sure to employ more men than the work requires. Again, in any dispute about the correctness of the time books, they are certain to side with their neighbors. This latter was one of the most annoying features I had to contend with, and while I was satisfied that in some cases the time was incorrectly kept, the larger part of the claims made were inspired by a desire to get all that was possible from the Government. This same spirit was plainly manifested in charging for supplies purchased, hence in future as little as possible should be purchased from local dealers. All supplies, tools, and materials that could possibly be required might be furnished to each quarter boat or camp in ample quantities, and as there is no perishable material required there would be no loss even if the parties were overstocked.

Third. The levees should be divided into sections of from 10 to 20 miles, the length of sections being proportioned to the probable amount of emergency work required, with an inspector in charge of each. This inspector should have authority to employ such subinspectors as he may require, but in conformity with the second suggestion. These inspectors should closely examine their sections as soon as it appears probable that a dangerous flood is reasonably certain. Some work, such as protecting exposed salients and spurs, or revetting caving banks where the levee approaches close to the river, could be more economically done before the water gets over the bank.

Fourth. Each foreman should accurately keep the time of the men under his orders. There should be for each section one mounted timekeeper who should collect from the foremen daily the time made and who should be held responsible for keeping time books whose accuracy would be beyond dispute.

Fifth. All employees from the grade of watchman up should have police powers to enforce all laws and regulations necessary for the preservation of the levee, notably those relating to stock and hogs running at large; driving upon or too close to the base of the levee, and erection of stock pens and other unauthorized structures upon it. Frequently the guards or others in authority have threatened to kill hogs rooting on the levee, but were in turn threatened with arrest and suit if they did so.

Sixth. There should be a perfectly working telephone line over the entire levee, with boxes wherever a camp or a quarter boat is located. During the last flood there was no telephonic communication from Butlers to Pecan Point, and this was extremely inconvenient. This line to be for local use only, connection with long-distance telephone not being recommended, as it might cause useless expense through the sending of unimportant messages by unauthorized parties, and probably also increase the number of "scare" messages, enough of which usually find their way to Memphis under present conditions.

Regarding the maintenance of the levee itself, it appears to me that the right of way should be so wide that a clear strip 50 feet wide from the base on both the land and the river side should be under the sole control of the authorities. All fences, roadways, and structures of any kind should be outside this strip. Such a reservation would not only aid largely in maintaining the levee intact, but would also in time of flood be a convenient source from which to obtain material for topping and other work.

Banquette.—Wherever the levee crosses a bayou, slough, or washout formed by a previous crevasse there should be built a banquette. In fact, all high levees should have this, as it largely retards saturation and sloughing.

Sod.—It is of importance that the slopes should have a thick, well rooted covering of Bermuda, and this can be easily obtained if the weeds are kept cut. Ordinarily one cutting just before the weeds go to seed will be sufficient. This can be done at a cost of from $8 to $10 per mile and is money well spent. If weeds are allowed to grow they will kill out the Bermuda.

Hogs and stock.—No stock of any kind, especially hogs, should be allowed upon the levee. If the land behind the levee should be under water by reason of a crevasse, then the owners should be made to floor the pens which they might be permitted for the time to erect upon the levee. The pens, however, should not cover the entire width of crown, but a passage for mounted employees should be left open.

Fences.—All fences crossing the crown of levee should be removed during the prevalence of a flood in order to permit quick passage of mounted employees.

Road crossings.—No cutting down of road crossings should be allowed. Even if parties promise to restore such places to their former elevation, they usually postpone it so long that when the water gets against it it finds green earth, easily saturated, there. Where the levee is exposed to wave wash some provision should be made to prevent this. It appears to me that this could be most easily attained by inducing the growth of willows, cottonwood, or other quick-growing shrubs along the foot of the riverside slope. This would form a permanent breakwater. Until this growth is high enough to accomplish the end a plank fence 10 to 12 inches high could be built near the top. This would be cheaper and much quicker work than the usual method of sacking.

Methods of treatment during flood.—Wherever it was practicable to do so the levee was topped by robbing the inner half of the crown and piling it upon the outer half. But where the levee was exposed to wave wash it was not safe to do this, and here the topping was done with filled sacks. But if lumber is available, then the former method is the quickest and cheapest. In that case it is only necessary to build a plank wall or fence along the river side of the crown and then pile the topping against it. If the crown is narrow, so that this topping must be correspondingly narrow, then there should also be a second plank wall set from 2 to 3 feet back of the outer one, within which to confine the topping. Sloughs were treated by first laying a mat or layer, about 6 inches thick, of brush, corn, or cotton stalks, or in the absence of either, hay. Then a course of thin lumber, or fence rails, about 10 inches apart, is laid, and upon this sacks filled with earth. At the base this sacking should have sufficient weight to counteract any tendency of the material on the slope to slide down. In other words, it should act as a retaining wall.

Boils were usually treated by building a hoop of sacks around them. For small ones, barrels with both ends open were successfully used. The lower edge of these should be well worked into the ground. Boils emitting only clear water need no treatment, but should be watched for signs of turbidness.

Wave wash can be checked either by a plank wall so set that the tops of the boards are a little above the crown of levee. Usually boards 10 to 12 inches wide are sufficient. They are nailed to stakes driven 6 feet apart into the levee. These should be driven deep enough to prevent lifting out by the buoyancy of the planks when the latter are partially submerged. Or, where there is no lumber handy sacks can be used, so laid that they will lie partially on the crown and partially on the slope, or cotton bagging can be laid so as to cover a little of the crown and more of the slope. This is held down by a filled sack every 5 or 6 feet. Or a boom of driftwood can be made by wiring together the logs or trees and letting this boom lie close to the levee. This, however, is resorted to only when no other material is readily available. When the boom is heavy a few filled sacks should be laid at intervals to act as a cushion for the impact of the boom during storms in order to prevent pounding against the levee.

It may be impracticable to do so, but it appears to me that the cross section of a levee should bear some proportion to the quality of the material used; that is, where easily saturated material is used the cross section should be wider than where stuff like impervious clays or buckshot is used.

Respectfully submitted.

AUG. J. NOLTY, *Assistant Engineer.*

Capt. E. W. VAN C. LUCAS,
Corps of Engineers, U. S. Army.

APPENDIX 2 E.

REPORT OF ASSISTANT ENGINEER CHAS. LE VASSEUR ON OPERATIONS DURING FLOOD OF 1903.

MEMPHIS, TENN., *April 15, 1903.*

CAPTAIN: I have the honor to make the following report on the levee-protection operations in the part of the White River levee district under my charge, during the high-water period from March 10 to April 6, 1903.

The part of the White River levee district covered by this report begins at the lower end of the Dixie break, station $\frac{33}{33+50}$ (342 R.), and extends to the back line of the Laconia Circle levee, which doubles on itself and joins the main levee at Laconia, Ark., station 74/75 M (373 R.). The total length of this levee line is 40 miles, 2,085 feet.

On March 10 I left Memphis, Tenn., for Helena, Ark., on the chartered steamer *Atlee*, with a small flat in tow, loaded with 20,000 sacks, 7 dozen shovels, 4 skiffs, 2 dozen wheelbarrows, and other sundry material needed on the levee-protection work in the White River levee district.

On March 11 I left 4,000 sacks, 3 dozen wheelbarrows, and 2 skiffs at Helena, Ark., and 4,000 sacks at Westover, Ark., for Mr. Purvis, assistant engineer.

On March 12, at 7.25 a. m., I went on board of the U. S. S. *Chisca* and reported to you, in accordance with your instructions. The *Chisca* took the flat from the steamer *Atlee* and left Friars Point, Miss., for the lower reach. I remained on the steamer *Chisca*, and on our way down 2,000 sacks and 2 dozen shovels were left at Old Town Landing, Ark., and 2,000 sacks at Modoc Landing, Ark.

Laconia Landing, Ark., was reached at 1 p. m. the same day, where the flat was left with the remaining property (8,000 sacks and 2 dozen wheelbarrows) in charge of Mr. de Beughen, United States inspector, who received instructions to make an immediate preliminary examination of the condition of the levees and to organize work where necessary. I went back with the U. S. S. *Chisca* to Helena, Ark., where I left the steamboat at 10.30 p. m., to await there the arrival of the U. S. S. *Mercury*, which I was to use as tender.

On March 13 I left Helena, Ark., on the U. S. S. *Mercury* at 8.45 a. m. for Dawsons Landing, Ark., where I arrived at 1.25 p. m. I left the boat and made an inspection of the entire line of levee left under my charge. By this inspection I found that the levees were in a poor condition to make a high-water fight and that a great deal of work would be required to stand the coming flood.

From station $\frac{33}{33+50}$ to station 43/44 milepost, the levee, with few small places excepted, was low and was necessitating to be topped at once.

The spur sike at station 34/40 was to be raised on 250 feet.

From station 38/14 to station 38/29, on the unfinished part of the Lacy's contract, the levee was not only low, but also very weak in section, the slope of the old levee having been robbed to complete the adjacent stations, and this on about 1,500 feet.

From station 47/4 to 47/31 and from station 48/4 to milepost 49/50 the grade was low and needed topping.

At all road crossings trouble had to be looked for, as the crossings were cut in the slope instead of being built out, thus reducing the levee section.

From Beiths Landing to Laconia Landing the levee was very narrow, but did not need any work at the time of this inspection.

On the Laconia levee, from Laconia to Henrico, several seeping places were showing up, also on the back levee line.

From station 59/40 to about milepost 67/68, and from milepost 72/73 to Laconia, the levee was low and topping necessary.

On mile 72, in front of Mr. Meacheam's place, a slough of 200 feet had occurred and several bad places had already developed.

The stage of the river on March 12, when I took charge of this high-water protection work, was at Helena, Ark., 45.4, and the elevation of the river at Dawsons Landing 182.25, Beiths Landing 173.70, Laconia, Ark., 172.00, and at Henrico Landing 168.78.

After conferring with Capt. Pat. Henry, president of the local levee board, and Mr. C. B. Blackburn, one of the directors, I organized the work all along the levee line, which I divided into two sections; one section from station $\frac{33}{33+50}$ to Beiths Landing, 51/52 M., 17 miles, 1,950 feet; the other from Beiths Landing to 74/75 M., 24 miles. Mr. de Beughen, United States inspector, was placed in immediate charge of the first section, and Mr. Douglas Jordan, United States inspector, in charge of the other. The patrolling and the keeping time of the labor were systematically organized.

On account of the long distance over which the grade of the levee had to be raised and the great quantity of sacks that such work would require, I directed all topping to be done by shovel work, reserving the sacks for short lengths of topping, slope revetment works, and the work which would have to be done at the end of the fight when dirt and shovel work would have become impracticable.

For the unfiinshed piece of Lacy's contract, teams and scrapers were hired, and the reinforcing of the levee was carried on in this manner until the satuated condition of the levee rendered this mode of operating impossible on account of the danger occasioned by the tramping of the mules. When this stage in the work was reached wheelbarrows were used, and the slope and banquette along this piece of levee were built up with sacks, and revetments were made of fence rails, brush or cane. The dirt or sacks had to be wheeled from 800 to 1,200 feet. This particular piece of work has been the cause of great apprehension during the entire fight. The work sloughed badly and the crown sunk several feet during construction. Hard work and close attention were required during the whole high-water period on this stretch.

The work on all the seeping places was attended to, using, as the case required, a revetment of brush and sacks or a sack loop.

As the stage of the river increased, numerous dangerous places developed which obliged to increase the force all along the levee line, and to proceed with the work day and night to keep the topping above water and to stop sloughing and seeping places. I had no trouble in obtaining the labor necessary for the work. The country back of the levee being overflowed by the water coming in through the Modoc and Dixie, 1897 breaks, the planters forced all their hands to work on the levee. The price paid for labor was $1.25 and $1.50 per day for subsisted and self-subsisting labor. The foremen were paid at a rate of $60 per month, excepting one foreman employed on the Lacy's contract protection work, who was paid at the rate of $90 per month, his work requiring a great deal more attention and direction than the others. The planters (landowners) who were employed by me as foremen did not receive compensation for their services. Team and scraper were paid $3.50 per day, this price including the driver. Tents and vacant houses were kindly placed by the people at my disposition without remuneration at different localities along the levee line to board and lodge the laborers.

The steamer *Mercury* was used entirely as tender, distributing sacks, materials, and supplies at places where needed, and transporting men. This boat had only a single crew, which, I take pleasure to mention here, has willingly worked day and night when necessary.

In the back levee of Laconia Circle, which is a private levee, and where the protection work was under the general direction of Capt. Pat. Henry, president of the local board, on March 25, at 5 p. m., a crevasse occurred at milepost 69/70. The gauge at Helena was 50.9, and the elevation of the water against the levee was 173. The grade of the levee at this point was 174. The levee in this locality is about 13 feet high and the cross section was good, but the material was very sandy. A seep hole located in the middle of the slope had been revetted and work was going on at the time the break occurred. The character of the break is known as "blow-out." The levee broke all at once on a width of 25 feet, 6 feet deep, and all efforts made by Captain Henry and the force under him to close the crevasse were of no avail. The rush of the water, the widening and deepening of the break, could not be stopped. The next morning the width was 180 feet, and its maximum, 480 feet, was reached on March 27. It was not anticipated at the time of the break, and soundings taken since prove it, that the cravasse would create a big hole on the land side, the current of the water being greatly diminished by the wooded character of the land back of the break and by the existence of a drain ditch.

All the Laconia Circle was overflowed through this break, and as the difference in elevation between the water surface at Laconia and that at Henrico is over 2 feet it was feared the backwater in the Circle, overtopping the front levee between Henrico and Huntington, might cause one or several breaks in that portion of levee. To prevent such an occurrence it was decided to attempt to keep the backwater in the Circle. This decision necessitated the retopping of the levee with dirt and sacks from milepost 60/61 to milepost 67/68, a distance of about 7 miles.

Before ordering this work done, as by its completion the cost of protection work would materially be increased, I reported to you, on board of the U. S. S. *Mississippi*, the condition of affairs. In compliance with the instructions you gave me, I proceeded at once with the topping and necessary work to confine the backwater in the Circle. This was successfully accomplished and a break in the front levee thus averted.

The damage caused directly by the break in the Laconia Circle was small outside of the ordinary damage to property due to a flood. The water filled up the Circle slowly three days, and the planters had ample time to take care of their stock and property.

On March 29 the river came to a stand. The gauge elevation at the Dixie break, milepost 34/35, was 183.75; at Beiths Landing, 177.68; at Laconia, milepost 55/56, 176.09, and at Henrico, milepost 60/61, 173.58. This high water was from 1 to 1.7 feet above the 1897 high water.

The river remained on a stand only a few hours and began to recede at once. The work was suspended on March 30. Only a small force was kept to attend to the bad places, as the levee being so completely saturated sloughing at the base was anticipated.

On April 2 and 3 a very severe windstorm occurred, and the levee from Beiths to Laconia and along the Laconia Circle had to be protected with sacking to prevent cutting by wave wash. The Laconia Circle levee suffered the most, the levee being subjected to wave wash from the river and from the inside water. During these two days about 5 miles of levee were protected against wave wash by sacking.

The stage of the river permitted to close all work on April 4. I then left the United States regular levee employees as guard on the levee, and the local board also employed some men for the purpose of guarding the different sloughing places until the river should have receded within its banks.

I left on April 6 for Memphis on board of the U. S. S. *Chisca*.

I have the honor to transmit herewith two profiles of the levee under my charge during this high water, one from station $\overset{33}{33+50}$ to Beiths Landing, 52 M., the other from Beiths Landing to milepost 74/75. These profiles show the elevation of the top of the levees as found before the high-water fight, the elevation of the high water (river and land side), the elevation of the topping placed during the high water, and the location and extent of the different protection work done.

It may be noted here that the last profile shows that the elevation of the back water in the Laconia Circle went above the maximum elevation of the water in the river, between milepost 61/62 and milepost 67/68, the maximum difference being 1 foot.

The summary of the high-water protection work done and shown in detail in the profiles is as follows:

On Mr. George de Beughen's section, length of levee, 17 miles 1,950 feet, from $\frac{33}{33+50}$ to 52 M. 9 miles of levee were topped and revetment and sacking work done on 21 bad places. This revetment work covers a total of 5,830 linear feet of levee.

On Mr. Douglas Jordan's section, length of levee, 24 miles, from 52 M. to 75 M., 12 miles of levee were topped to stand the high water from the river; 7 miles were retopped after the break in the back line to confine the water in the Circle; 22 bad places were revetted and sacked, this revetment covering a total of 4,000 linear feet. During the windstorm mentioned above 4 miles 4,880 feet of levee were sacked to prevent cutting by wave wash.

This is a summary of the expenses of the high-water protection operations from station $\frac{33}{33+50}$ to 75 M.

Superintendence (assistant engineer, inspectors, and levee employees)	$498.83
Foremen and watchmen	586.50
Labor	4,435.73
Subsistence for labor	272.04
Teams and scrapers (hired)	271.25
Steamboat expenses (crew)	389.88
Subsistence steamboat	207.70
Coal steamboat	200.95
Sacks, material, and engineering supplies	2,000.00
Total	8,862.88

This total brings the cost of the high-water fight to $206.11 per mile of levee protected—that is, mile where work has been done.

Before closing this report I wish to express my thanks to Capt. Pat. Henry and Mr. C. B. Blackburn, president and director of the local levee board, for the help and assistance they so kindly extended during the high-water period; also to the people all along the line for their kind treatment and willingness.

I desire also in this connection to place on record the very willing and efficient manner in which the inspectors and their assistants connected with this work performed the duties allotted to them during this high-water fight: Messrs. George de Benghen, Douglas Jordan, inspectors; B. B. Nally, J. W. Burton, E. C. Graves, as foremen; C. B. Coffey and Ed. Blackburn, as timekeepers.

Respectfully submitted.

Chas. LeVasseur, *Assistant Engineer.*

Capt. E. W. Van C. Lucas,
Corps of Engineers, U. S. Army.

SUMMARY STATEMENT OF HIGH-WATER PROTECTION WORK DONE DURING THE HIGH-WATER PERIOD FROM MARCH 10 TO APRIL 6, 1903, FROM STATION $\frac{33}{33+50}$ TO MILEPOST 74/75, WHITE RIVER LEVEE DISTRICT.

[To accompany report of operations of Charles LeVasseur, assistant engineer, dated April 15, 1903.]

FIRST SECTION.

From station $\frac{33}{33+50}$ to Beiths Landing, milepost 51/52. (George de Benghen, inspector.)

On mile section 34.—From station $\frac{33}{33+50}$ to station $\frac{33}{48}$, topping 2 feet high, dirt and shovel work.

On mile section 35.—From station $\frac{34}{1+50}$ to milepost 35/36, topping, dirt, and shovel work.

At station $\frac{34}{40}$, spur dike, land side topped with sacks, seven high, two wide, 250 feet long.

On mile section 36.—From milepost 35/36 to station $\frac{35}{12+50}$, topping, dirt, and shovel work.

From station $\frac{35}{15+00}$ to milepost 36/37, topping 2 feet high, dirt and shovel work.

At station $\frac{35}{27+60}$ to $\frac{35}{28+30}$, seep holes revetted with brush and sacks.

At station $\frac{35}{52}$ to milepost 36/37, seep holes and sloughing revetted with brush and sacks.

On mile section 37.—From milepost 36/37 to station $\frac{36}{25+00}$, topping 2 feet high, dirt and shovel work.

From station $\frac{36}{38+50}$ to milepost 37/38, topping with dirt and shovel work; this topping was also overtopped with sacks.

From milepost 36/37 to station $\frac{36}{4+50}$, seep holes and sloughing revetted with brush and sacks. Bad piece of levee, very soft and poor material.

At station $\frac{36}{7+00}$, 50 feet long, and station $\frac{36}{11+00}$, 100 feet long, seep holes revetted with brush, mat, and sacks.

At station $\frac{36}{48+49}$, seep holes, brush and cane revetment, and sacking.

On mile section 38.—From milepost 37/38 to station $\frac{37}{3+00}$, light topping with dirt.

From station $\frac{37}{5+50}$ to $\frac{37}{14+50}$ and $\frac{37}{17}$ to $\frac{37}{18+60}$, light topping with dirt and sacks.

From station $\frac{37}{27}$ to $\frac{37}{28+70}$, $\frac{37}{33+20}$ to $\frac{37}{36+00}$, $\frac{37}{46}$ to $\frac{37}{48}$, and $\frac{37}{49+50}$ to $\frac{37}{49+80}$, light dirt topping, shovel work.

At station $\frac{37}{6+60}$ to station $\frac{37}{10+50}$, levee very soft and sloughing; banquette too low and without slope, seeping badly, revetted with rails, brush, and sacks.

At station $\frac{37}{13+30}$, levee soft, brush and sack revetment 40 feet long.

At station $\frac{37}{24+00}$ to $\frac{37}{27+50}$, levee soft and sloughing, seep holes, troubles due to bad banquette and road crossing cut in levee slope; revetted with rails, brush, and sacks.

At station $\frac{37}{47+20}$ to $\frac{37}{50+00}$, levee had been plowed and broken by Contractor Lacy; seep holes and sloughing; brush and sack revetment.

On mile section 39.—From station $\frac{38}{14+00}$ to $\frac{38}{28+00}$, unfinished Lacy's contract. Levee was left in very bad condition; old levee robbed to complete adjacent stations. Part of protection work done by scraper work, as long as stage of water permitted. Levee sinking, sloughing, and seeping badly. Has been in very dangerous condition during the entire high-water period. Revetted with mattress made of brush, cane, and fence rails; banquette and side of levee on entire length built out with sacks; topping of dirt and wheelbarrow work and sacks. Dirt had to be hauled from 800 to 1,200 feet.

From station $\frac{38}{34+50}$ to milepost 39/40, topping dirt and shovel work; overtopped in places with sacks.

At station $\frac{38}{40+20}$ to $\frac{38}{41+50}$, seep holes revetted with brush and sacks.

At station $\frac{38}{46+50}$ to milepost 39/40, seep holes; levee was very soft; revetment of brush and sacks.

On mile section 40.—From milepost 39/40 to milepost 40/41, topping dirt placed with scrapers first and finished by shovel work 2 feet high.

On mile section 41.—From milepost 40/41 to station $\frac{40}{9+00}$, topping with dirt, shovel work.

From station $\frac{40}{10+00}$ to milepost 41/42, topping, dirt placed with scrapers first and finished by shovel work, 2 feet high. This work was retopped in places with sacks.

At milepost 40/41 to station $\frac{40}{1+20}$ seep holes revetted with brush and sacks.

From station $\frac{40}{23+30}$ to $\frac{40}{25+00}$ seep holes revetted with brush and sacks.

From station $\frac{40}{32+50}$ to $\frac{40}{40+00}$ levee very soft, seepy, and sloughing. Dangerous piece of levee; bad material, probably quicksand; revetted with brush and sacks, subjected to wave wash.

On mile section 42.—From milepost 41/42 to milepost 42/43, topping, dirt placed by scraper first and finished by shovel work.

At station $\frac{41}{42+50}$ and station $\frac{41}{49+70}$ road crossing filled with sacks.

From station $\frac{41}{45+50}$ to $\frac{41}{46+70}$ seep holes revetted with brush and sacks.

On mile section 43.—From milepost 42/43 to station $\frac{42}{8+00}$, station $\frac{42}{7+50}$ to station $\frac{42}{25+00}$, and from station $\frac{42}{28+80}$ to milepost 43/44, topping, dirt and shovel work and retopped in places with sacks.

At station $\frac{42}{39}$ to $\frac{42}{42+00}$, seep holes; levee very soft; very sandy material; revetted with brush and sacks.

On mile section 44.—From milepost 43/44 to station $\frac{43}{1+00}$, station $\frac{43}{31}$ to $\frac{43}{36+60}$, station $\frac{43}{44}$ to $\frac{43}{46}$, and from station $\frac{43}{49}$ to milepost 44/45, topping, dirt and shovel work.

On mile section 45.—From milepost 44/45 to station $\frac{44}{4+00}$ light dirt topping.

On mile section 48.—From station $\frac{47}{4+00}$ to station $\frac{47}{31+00}$, topping, dirt and shovel work, topped with sacks: topping revetted on river side with sacks to prevent cutting by wave wash.

On mile section 49.—From station $\frac{48}{4+00}$ to $\frac{48}{12}$, station $\frac{48}{13}$ to $\frac{48}{25}$, station $\frac{48}{27}$ to $\frac{48}{30}$, station $\frac{48}{32}$ to $\frac{48}{40}$, and from station $\frac{48}{46}$ to $\frac{48}{52+50}$, topping, dirt and shovel work; sacking in places.

On mile section 50.—From station $\frac{49}{46}$ to $\frac{49}{47}$ seep holes revetted with brush and sacks.

SECOND SECTION.

From Beiths Landing, milepost 51/52 to milepost 74/75. (Mr. Douglas Jordan, inspector.)

On mile section 52.—From station $\frac{51}{14}$ to $\frac{51}{22}$ and from $\frac{51}{40}$ to $\frac{51}{41}$ wave wash protected with sacks, river side.

From station $\frac{51}{45}$ to $\frac{51}{47}$ topping with sacks.

On mile section 53.—From station $\frac{52}{13}$ to $\frac{52}{23+50}$, $\frac{52}{26}$ to $\frac{52}{27}$, $\frac{52}{28}$ to $\frac{52}{42}$, and from $\frac{52}{44}$ to $\frac{52}{51}$ topping with sacks and backing of dirt.

On mile section 54.—From station $\frac{53}{10}$ to $\frac{53}{18+50}$, $\frac{53}{20}$ to $\frac{53}{24}$, and from $\frac{53}{38}$ to milepost 54/55 topping with sacks.

From station $\frac{53}{24}$ to $\frac{53}{37}$ wave wash protected with sacks, river side.

On mile section 55.—From station $\frac{54}{5+60}$ to $\frac{54}{10+80}$, $\frac{54}{22+50}$ to $\frac{54}{26+90}$, and from $\frac{54}{49}$ to station $\frac{54}{50+70}$ topping with sacks.

From station $\frac{54}{14}$ to $\frac{54}{37}$ wave wash protected with sacks, land side.

At station $\frac{54}{42+50}$ to $\frac{54}{43+50}$ seep holes at road crossing revetted with brush and sacks.

From station $\frac{54}{45}$ to milepost 55/56 seep holes revetted with brush and sacks.

On mile section 56.—From station $\frac{55}{14+50}$ to $\frac{55}{15+70}$ and from station $\frac{55}{23+60}$ to $\frac{55}{30}$ topping with sacks.

From milepost 55/56 to station $\frac{55}{2+00}$ seep holes revetted with brush and sacks.

From station $\frac{55}{3+00}$ to $\frac{55}{6+00}$ wave wash protected with sacks.

At station $\frac{55}{15}$ road crossing seeping badly; revetted with brush and sacks.

From station $\frac{55}{18}$ to $\frac{55}{24}$ and from $\frac{55}{29}$ to milepost 56/57 wave wash protected with sacks on the land side.

On mile section 57.—From station $\frac{56}{5}$ to $\frac{56}{26}$ and from station $\frac{56}{35}$ to $\frac{56}{37}$ wave wash protected with sacks and log boom on the land side.

On mile section 59.—At station $\frac{58}{20}$, road crossing, seep holes revetted with sacks.

On mile section 60.—From station $\frac{59}{10}$ to station $\frac{59}{46}$ wave wash protected with sacks on the land side.

On mile section 61.—From milepost 60/61 to milepost 61/62 topping 2 feet high, dirt and shovel work. This topping was topped over again with sacks after the back levee break.

On mile section 62.—From milepost 61/62 to $\frac{61}{27}$, $\frac{61}{28}$ to $\frac{61}{31}$, $\frac{61}{31+50}$ to $\frac{61}{34+50}$, $\frac{61}{38}$ to $\frac{61}{43}$, and from $\frac{61}{47+60}$ to milepost 62/63 topping with dirt and shovel work. This topping was topped over again with sacks after the break occurred.

From milepost 61/52 to station $\frac{61}{16}$, $\frac{61}{35}$ to $\frac{61}{37}$, and from station $\frac{61}{45}$ to $\frac{61}{50}$ wave wash protected with sacks, land side of levee.

On mile section 63.—From milepost 62/63 to milepost 63/64, topping, dirt, shovel work, and sacks. This mile was topped over again with sacks after the break occurred.

From station $\frac{62}{15}$ to $\frac{62}{18}$ and $\frac{62}{35}$ to $\frac{62}{39}$ wave wash protected with sacks on the land side.

On mile section 64.—From milepost 63/64 to milepost 64/65, topping, dirt and shovel work and sacks. This mile was topped over again with sacks after the break.

From station $\frac{63}{5}$ to $\frac{63}{6}$ and $\frac{63}{23}$ to $\frac{63}{24}$ wave wash protected with sacks on the land side of the levee.

From station $\frac{63}{50}$ to $\frac{63}{52+50}$ seep holes revetted with brush and sacks.

On mile section 65.—From milepost 64/65 to milepost 65/66, topping, dirt and shovel work and sacks. This mile was topped over again with sacks after the break.

From station $\frac{64}{23}$ to $\frac{64}{24}$ seep holes revetted with brush and sacks.

From station $\frac{64}{32}$ to $\frac{64}{47}$ wave wash protected with sacks, land side.

On mile section 66.—From milepost 65/66 to milepost 66/67, topping with dirt and sacks. This mile was retopped with sacks after the break occurred.

From station $\frac{65}{35}$ to $\frac{65}{37}$, seep holes, revetted with brush and sacks.

From station $\frac{65}{41}$ to milepost 66/67, wave wash protected with sacks on the land side.

On mile section 67.—From milepost 66/67 to milepost 67/68, topping with dirt and sacks. This mile was also retopped with sacks after the break from milepost 66/67 to station $\frac{66}{45}$.

From station $\frac{66}{44}$ to $\frac{66}{47}$, seep holes, revetted with brush and sacks.

On mile section 68.—From milepost 67/68 to milepost 68/69, topping, dirt, shovel work, and sacks.

From station $\frac{67}{8}$ to $\frac{67}{10}$ and $\frac{67}{18}$ to $\frac{67}{21+50}$, wave wash, land side protected with sacks.

From station $\frac{67}{40}$ to $\frac{67}{41}$, seep holes, revetted with brush and sacks.

On mile section 69.—From milepost 68/69 to milepost 69/70, topping with dirt, shovel work, and sacks.

From station $\frac{68}{27}$ to $\frac{68}{28}$ and from $\frac{68}{51}$ to milepost 69/70, seep holes, revetted with brush and sacks.

On mile section 70.—From milepost 69/70 to station $\frac{69}{5}$, topping with dirt, shovel work, and sacks.

Break occurred March 25 at 5 p. m. between milepost 69/70 and station $\frac{69}{4+80}$. The seeping and sloughing places between these stations were under revetment at time of break.

From station $\frac{69}{9}$ to $\frac{69}{17}$ and from $\frac{69}{22}$ to $\frac{69}{33}$ and from $\frac{69}{40}$ to $\frac{69}{46}$, wave wash, land side protected with sacks.

On mile section 71.—From station $\frac{70}{4}$ to $\frac{70}{5}$, $\frac{70}{16}$ to $\frac{70}{45}$, and from $\frac{70}{48}$ to milepost 71/72, wave wash, land side protected with sacks.

From station $\frac{70}{20}$ to $\frac{70}{25}$, $\frac{70}{32}$ to $\frac{70}{39}$, $\frac{70}{46}$ to $\frac{70}{48}$, and $\frac{70}{49}$ to $\frac{70}{52}$, topping with dirt work, and sacks.

From station $\frac{70}{10}$ to $\frac{70}{11}$, $\frac{70}{35}$ to $\frac{70}{37}$, and $\frac{70}{47}$ to $\frac{70}{48}$, seep holes, revetted with brush and sacks.

On mile section 72.—From station $\frac{71}{27}$ to milepost 72/73, topping with sacks.

From station $\frac{71}{35}$ to $\frac{71}{37}$ and $\frac{71}{39}$ to $\frac{71}{41}$, seep holes and sloughing, protected with brush and sacks.

On mile section 73.—From milepost 72/73 to station $\frac{72}{27}$ and from $\frac{72}{28+50}$ to $\frac{72}{40+60}$, also from $\frac{72}{42+50}$ to $\frac{72}{45}$ and $\frac{72}{46+50}$ to milepost 73/74, topping with sacks.

From station $\frac{72}{15}$ to $\frac{72}{17}$, $\frac{72}{28}$ to $\frac{72}{29}$, $\frac{72}{49+50}$ to $\frac{72}{50+60}$, seep holes, revetted with brush, mat, and sacks.

On mile section 74.—From station $\frac{73}{4+50}$ to $\frac{73}{29+50}$, topping with sacks.

From station $\frac{73}{20+20}$ to $\frac{73}{21+50}$ and $\frac{73}{24}$ to $\frac{73}{24+50}$, seep holes and sloughing, revetted with brush and sacks.

TOTAL SUMMARY OF WORK DONE FROM STATION $\frac{33}{33+50}$ TO MILEPOST 74/75.

[40 miles 2,085 feet.]

Twenty-one miles, 3,520 feet of levee topped.
Seven miles of levee retopped after the break.
Forty-three bad places revetted with brush, mat, and sacks, making a total of 9,830 feet of revetment.
Four miles, 4,880 feet of levee protected against wave wash.

Tabulated statement of high-water elevations from station $\frac{33}{33+50}$ to milepost 74/75, White River levee district. High water, March, 1903.

[To accompany report of Chas. LeVasseur, assistant engineer, dated April 15, 1903.]

Station.	Elevation, high water, river side.	Elevation, maximum, land side.	Station.	Elevation, high water, river side.	Elevation, maximum, land side.
Station $\frac{33}{33+50}$	185.74	183.95	Milepost 53/54	177.00	174.00
Milepost 34/35	185.75	183.94	Milepost 54/55	176.73	173.60
Station $\frac{34}{40}$	185.81	181.20	Milepost 55/56	176.09	173.56
Milepost 35/36	185.82	180.59	Milepost 56/57	175.77	173.56
Milepost 36/37	185.91	179.53	Milepost 57/58	175.74	173.54
Milepost 37/38	185.76	176.00	Milepost 58/59	175.30	173.54
Milepost 38/39	185.63	175.19	Milepost 59/60	174.60	173.60
Milepost 39/40	185.32	174.59	Milepost 60/61	173.58	173.58
Milepost 40/41	185.67	174.38	Milepost 61/62	173.20	173.65
Milepost 41/42	184.00	174.19	Milepost 62/63	172.76	173.65
Milepost 42/43	182.92	174.01	Milepost 63/64	172.85	173.65
Milepost 43/44	181.95	173.89	Milepost 64/65	172.96	173.65
Milepost 44/45	180.59	173.82	Milepost 65/66	173.00	173.60
Milepost 45/46	180.49	173.70	Milepost 66/67	172.98	173.60
Milepost 46/47	180.40	173.55	Milepost 67/68	172.00	172.00
Milepost 47/48	180.30	173.50	Milepost 68/69	172.75	172.75
Milepost 48/49	180.15	173.45	Milepost 69/70	173.00	173.00
Milepost 49/50	179.63	173.40	Milepost 70/71	173.10	173.10
Milepost 50/51	178.68	173.37	Milepost 71/72	173.20	173.20
Milepost 51/52	177.68	173.28	Milepost 72/73	173.20	173.20
Milepost 52/53	177.54	174.00	Milepost 73/74	173.28	173.28
			Milepost 74/75	173.28	173.28

APPENDIX 2 F.

REPORT OF ASST. ENGINEER M. GARDNER ON OPERATIONS DURING FLOOD OF 1903.

MEMPHIS, TENN., *April 30, 1903.*

CAPTAIN: I have the honor to submit the following report on the high-water protection work in the Upper Yazoo district during the high water of 1903.

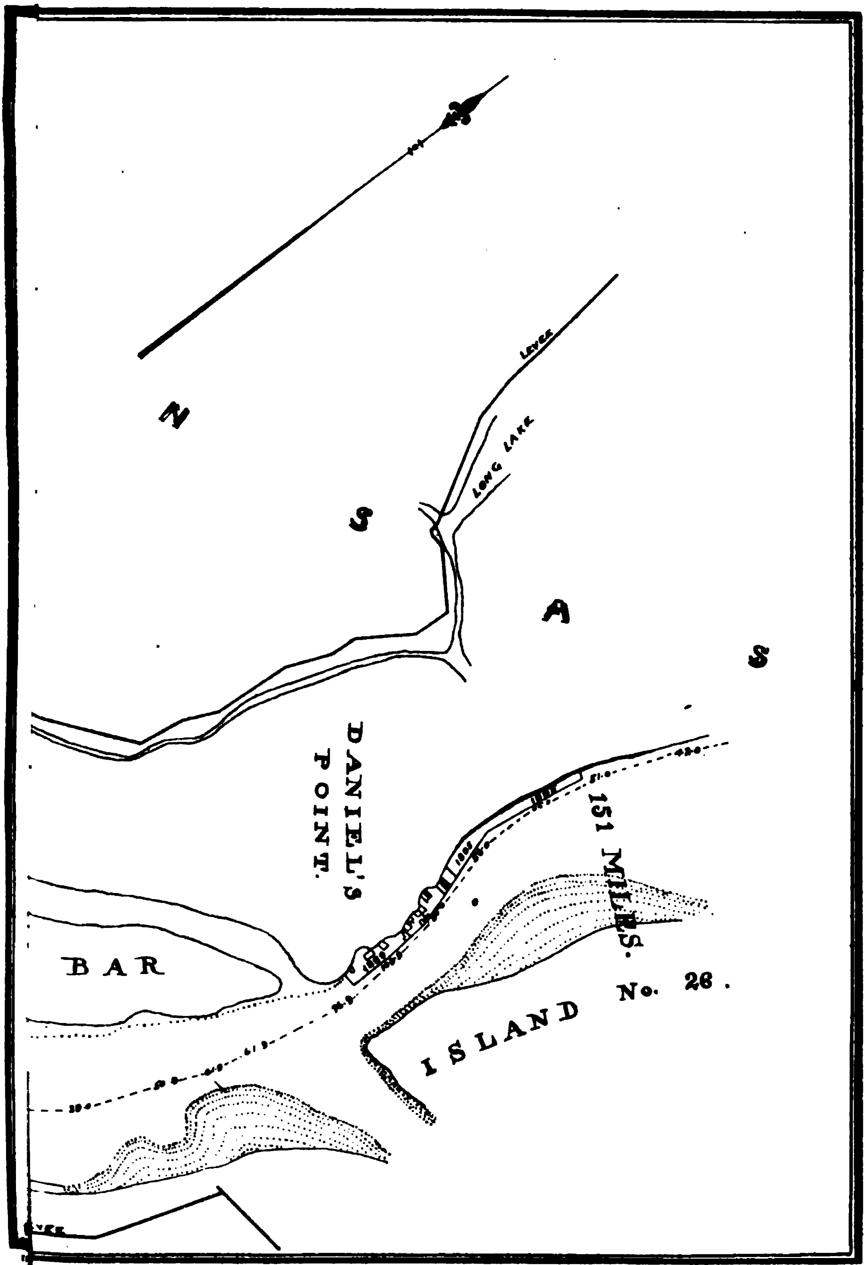
The high-water work in this district was undertaken by the levee board; the only assistance rendered by the United States was the loan of some barges and quarterboats.

From the upper end of the district to mile 36 there was but little work necessary other than keeping the levee well guarded, both night and day. On mile 36, at a salient where a spur dike had been built, the very swift current began washing the dike away, and for a while it was feared the dike would be washed entirely away and take part of the levee with it. After considerable work the end of the dike was revetted with brush and sacks and gave no further trouble.

From mile 36 to the vicinity of Burks Landing, mile 84, no very dangerous places developed. At Burks Landing a very large and dangerous sand boil developed, discharging a very considerable amount of sand. It was first treated by building a loop of sacks around it to pond the water and prevent the escape of the material it was discharging. After being made comparatively safe in this manner, a sublevee of earth was constructed, inclosing a considerable area, which was filled with water to act as a counter pressure to the water on the river side of the main levee.

At the end of the front levee, mile 91, was another place that gave a good deal of trouble. A bulkhead had been constructed at the end of the levee to protect it from washing. This gave away, threatening to take part of the levee with it. It was feared that if this levee caved off to any extent, the Ward Lake levee, 5 miles in length, would be overtopped. To guard against such a contingency, the Ward Lake levee was topped with earth.

The back levee, from its junction with the Ward Lake levee, mile 109 to mile 116, gave very little trouble. From mile 116 to the lower end of the district, mile 127, required considerable work. On miles 117, 120, 121, and 122, about 2 miles in extent, the levee was too low to be considered safe, so it was topped with earth before the river reached its highest stage. The most dangerous place in the district was in the vicinity of Malones Landing, on miles 119 and 120, where a salient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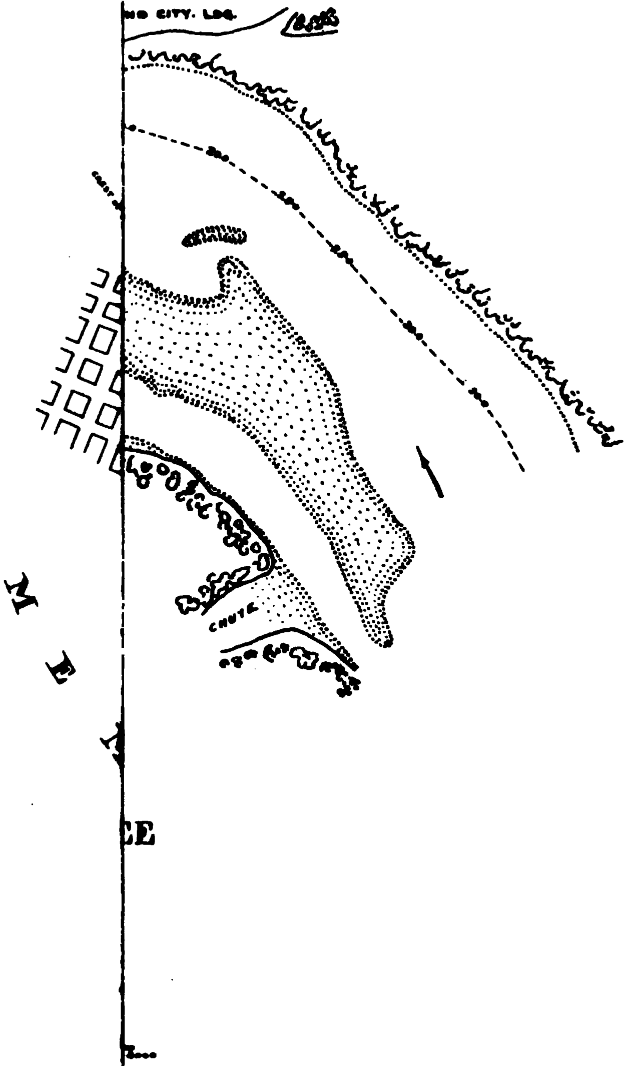

To accompany my annual report for
the fiscal year ending June 30. 1903.

Captain Corps of Engr's. U. S. A.

P. H. Lohman, Del.

THE NORRIS PETERS CO. PHOTO-LITHO.

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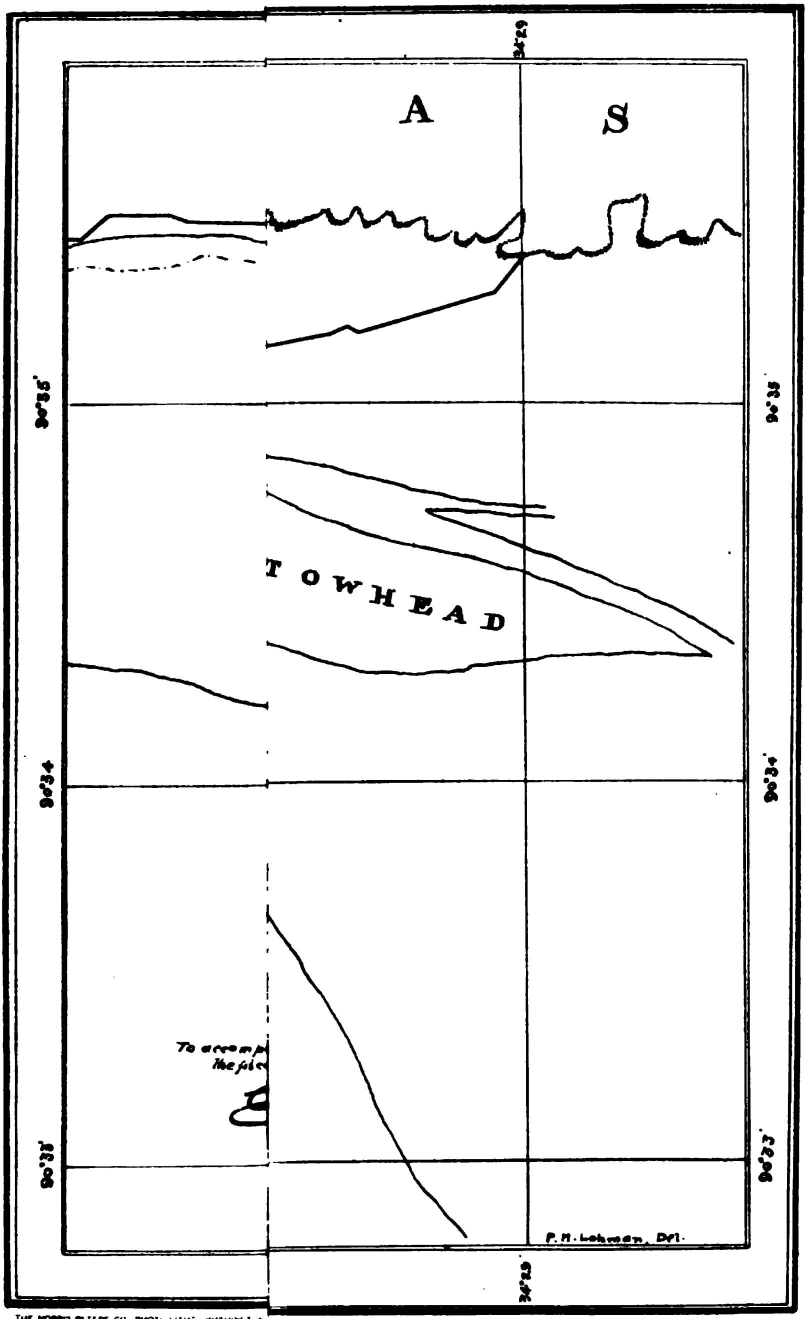

THE NORRIS PETERS CO. PHOTO-LITHO. WASHINGTON

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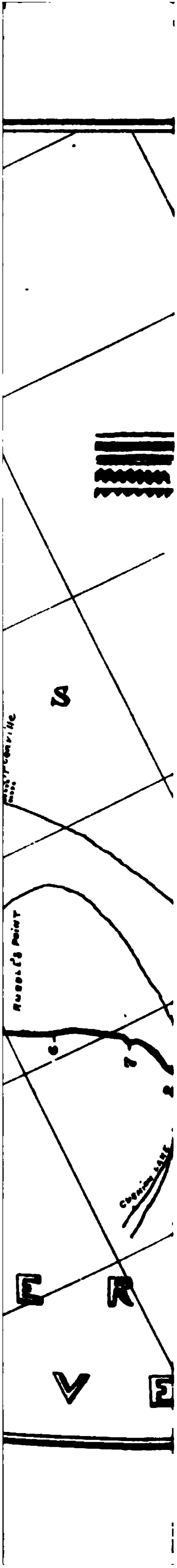
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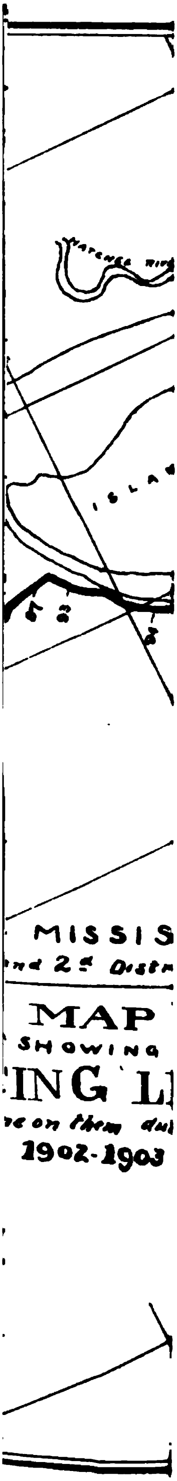
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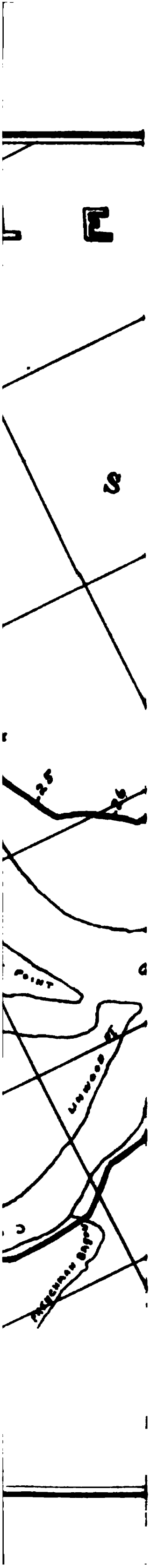
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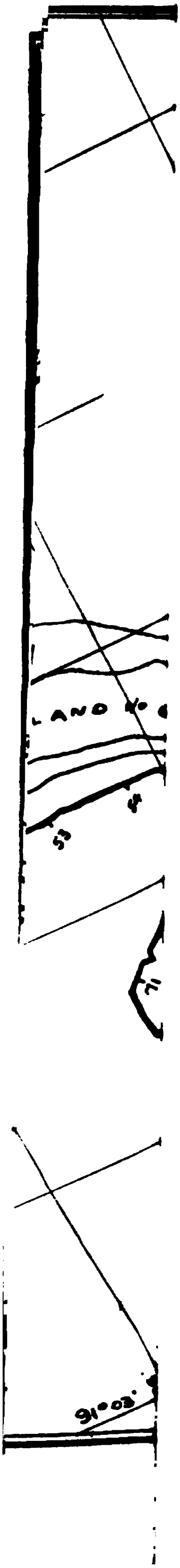
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[illegible]

in the old levee was caving in the river, so a protection levee had to be constructed around the threatened point. Part of this protection levee was constructed of a sandy material. When the water began to rise the basin between the two levees filled with water; it was then that the sandy part of the new work began to seep and show other signs of weakness. To correct that fault a layer of "buckshot" material was placed on the river side of the new work, which proved very effective.

In addition to the above-mentioned places where work was necessary, numerous sand boils developed at various places in the district that required more or less attention, some of them quite large and discharging a considerable amount of sand, while others discharged no material whatever. Whenever these boils were of considerable dimensions and discharged any material they were treated by building a loop of sacks around them to pond the water and prevent the escape of the material.

Perhaps the most critical time during the high water was on April 3 during a very high wind. At every exposed place in the district the waves did considerable damage, and at some places it required the utmost efforts to prevent a break.

It is a fact worthy of note that no sloughing occurred to speak of in the entire district. The rear slope in a good many places seeped freely, but showed no disposition to slough. That may be partly accounted for by the very favorable weather conditions that existed during the high water.

I submit with this report a profile showing the high-water lines of 1897 and 1903, so a comparison can be made of the two waters. From the upper end of the district to the lower end of mile 4 the two water planes are level, the 1903 being 2.8 above that of 1897. From the lower end of mile 4 to the lower end of mile 24 the 1903 plane is nearly a uniform height above that of 1897, and from that point the 1903 high water approaches that of the 1897 until, at the lower end of mile 30, the two waters are the same and remain so for a mile. The extension of the levees on the Arkansas side since the 1897 water caused the 1903 to go higher than the one of 1897 at the upper end of the district.

From mile 31 to the lower end of 36 the 1903 water again goes above that of 1897, which is due, I think, to the extension of the levee by the St. Francis board from the end of the Government levee, just above Whitehall, Ark., up the river about 7 miles.

From mile 36 to about the middle of 63 the 1903 water was below that of 1897, and from the middle of 63 to the lower end of 65 it gets above the 1897 water. The 1903 water being higher than the 1897 one on miles 64 and 65 is due perhaps to a local cause, two spur levees, one at the upper and one at the lower end.

Any peculiarities that the two high-water planes present from mile 65 to the lower end of the district was due, I think, to the breaks on the Arkansas side in 1897 and the closing of most of them since then.

Respectfully submitted.

M. GARDNER,
Assistant Engineer.

Capt. E. W. VAN C. LUCAS,
Corps of Engineers, U. S. Army.

APPENDIX 3.

REPORT OF CAPT. CHARLES L. POTTER, CORPS OF ENGINEERS, UPON OPERATIONS IN THE THIRD DISTRICT.

UNITED STATES ENGINEER OFFICE,
Memphis, Tenn., May 20, 1903.

COLONEL: I have the honor to submit the following report of operations in the Third district, Improving Mississippi River, from May 1, 1902, to May 1, 1903:

The Third district extends from the Coahoma-Bolivar County line on the left bank (365 L.), and the mouth of White River on the right bank (393 R.), to the latitude of Warrenton, Miss. (607 L.). In its improvement works of bank protection have been executed at Lake Bolivar front, Ashbrook Neck, Greenville Harbor, Lake Providence, and Delta Point; the systematic improvement of Lake Providence reach was attempted, and levees have been constructed and enlarged in the Lower Yazoo and Upper Tensas levee districts. All of these localities are shown on the accompanying map of the Third district.

The operations of the past year have included repairs to the revetments at Lake Bolivar front, Ashbrook Neck, Greenville, and Lake Providence, the construction and maintenance of levees, quarrying and towing stone, towing brush, poles, and stone for the season's work, the repair and care of plant, the usual surveys of bank revetment and of Lake Providence reach, and the high-water operations incident to the flood of 1903.

LAKE BOLIVAR FRONT (417 MILES BELOW CAIRO).

The revetment at this place was built to hold a bank whose caving endangered a large levee across the head of Lake Bolivar. About 4,250 linear feet of revetment were constructed in 1888-89, and repairs were made in 1889, 1892, and 189. Details of the work are given in the Annual Reports of 1889, page 2704; 1890, page 3252; 1893, page 3752, and 1894, page 2919, and maps accompany the reports of 1889 and 1890.

During the past year repairs were made to cover the small breaks in the upper bank pavement mentioned in my last annual report.

The revetment at this place is protected to some extent by a narrow bar formed a short distance from the work, and the tendency of the river appears to be toward taking this outside channel at ordinary stages, the caving of Island 3 above and a hard point at the lower end of the island throwing the current away from the revetment. At the higher stages the river comes across from the upper side of Calks Point, striking directly in on the upper bank pavement, tending to disturb it. This, however, does not much endanger the revetment, as repairs are easily made in the upper bank work.

The revetment is in good condition for a length of 3,775 feet. The expenditures during the past year have been $5,942.72, and the total expenditures on this work have been $151,300.76.

ASHBROOK NECK (446 MILES BELOW CAIRO).

The revetment at this place was built to prevent a threatened cut-off, the minimum distance across the neck having been reduced to about 2,000 feet. About 2,820 linear feet of revetment were constructed in 1890-91, 4,300 feet in 1891-92, 2,610 feet in 1892-93, 1,475 feet in 1894-95, and repairs, principally to upper bank paving, were made in 1893-94 and 1897-98. Repairs were also made in 1899-1900. In the season 1900-1901, 4,000 feet of standard mat 250 feet wide were laid to reinforce the upper half of the work, and one large break repaired. A levee 7,[illegible] feet long was built along the axis of the neck in 1891-92 to prevent flow across the neck, but it was destroyed in the next flood. Details of the work are given in the Annual Reports of 1891, page 3639; 1892, page 3170; 1893, page 3752; 1894, page 2920; 1895, page 3805; 1898, page 3370; 1899, page 3537; 1900, page 4825, and 1901 (Sup.), page 267. Maps accompany the reports of 1892, 1893, 1900, and 1901.

The project for this work for last year contemplated the extension of the revetment upstream to cover the pocket which was being formed, threatening the head of the revetment, the repairing of a break between ranges 96 and 98, and the extension of the reinforcing fascine mat as far downstream as funds would permit. The revetment was extended about 500 feet at the upper end, the break was repaired, and one reinforcing mat 940 feet long was put in. For details of the season's work, see accompanying reports of Mr. Arthur Hider and Mr. George C. Thomas.

The revetment covers a distance of nearly 10,500 feet, and is in good condition, but may need some repairs in the future; and at least one channel mat, covering the space from ranges 92 to 104, should be put in during the coming season, as this covers points where several breaks have occurred. It is also considered advisable to extend this reenforcement downstream the length of two, or possibly more, mats.

The expenditures during the last year have been $42,395.49 and the total expenditures on this work have been $609,852.74.

GREENVILLE HARBOR (478 MILES BELOW CAIRO).

The revetment at this place was built to protect the town of Greenville, which was rapidly caving into the river when the work was begun, in 1887. The first project was to hold the bank with submerged spur dikes consisting of cribs resting on foundation mats. In 1887, 1888, and 1889 twelve crib dikes were built and one longitudinal pile dike, and mats were placed between some of the spur dikes. Caving continued, however, in the bend above, and during the flood of 1891 the upper dikes were flanked, four spur dikes and the longitudinal pile dike being carried away. The revetment of the bank above the remaining dikes was then begun, 6,600 linear feet being built in 1891-92, 4,450 feet in 1892-93, and 3,087 feet in 1894-95, woven mats being used in all this work. Repairs were made to upper bank paving in 1893 and 1894. In the flood of 1894 the upper remaining spur dike was carried away, leaving seven spur dikes still in position. Breaks in the revetment were repaired by the construction of about 677 linear feet of new revetment in 1896, using fascine mats, and 1,850 feet in 1897-98, together with considerable new upper bank work. In 1899 extensive repairs were made by sinking 5,108 linear feet (14,666 squares) of channel mat and ten pocket mats, amounting to about 2,843 squares, and paving 5,882 squares of bank. Three small dikes were also built to prevent wash on top of the bank which threatened to flank the line. Some small repairs were made in 1899-1900. In the season 1900-1901 two breaks were repaired and about 1,100 feet of channel mat were built to reenforce the old type of mat.

The details of the above operations are given in the Annual Reports of 1888, page 2280; 1889, page 2706; 1890, page 3240; 1892, page 3173; 1893, page 3753; 1894, page 2920; 1895, page 3805; 1897, page 3726; 1898, page 3370; 1899, page 3538; 1900, page 4825, and 1901 (Sup.), page 267. Maps accompany the reports of 1888, 1889, 1890, 1892, 1893, 1899, 1900, and 1901.

During the past year the break between ranges 104 and 107, reported in my annual report for 1902, has been repaired, the upper bank pavement extended into the pocket above the work, and a pocket mat built at the extreme upper end to overcome the tendency of the current to cut in behind the head of the work. For details of this work see accompanying reports of Mr. Arthur Hider and Mr. George C. Thomas.

Two small breaks have recently occurred in this revetment, one near the foot of Davis street and the other near the foot of Union street, which will need repairs during the coming season. There is also a distance of about 600 feet (ranges 120 to 126) where the old type of mat should be reenforced by the new standard.

The length of revetment at this place is about 11,600 feet, and about 2,900 feet is protected by the dikes below, all of which revetment appears to be in good condition except at the points above mentioned. The expenditures during the past year have been $20,640.18 and the total expenditures have been $898,753.55, not including $42,277.10 contributed by the town of Greenville in 1887.

LAKE PROVIDENCE REACH (517 TO 552 MILES BELOW CAIRO).

Earlier works.—This was one of the reaches first selected by the Mississippi River Commission for systematic treatment. The least low water depths on its crossings before its improvement was undertaken are variously reported as 4½ and 5 feet. The original project provided for giving the low-water channel an approximately uniform width of 3,000 feet by constructing contraction works, closing all the chutes, and holding the caving banks. Instead of covering the entire reach of 35 miles, however, as originally intended, the works as built were confined to a reach of about 20 miles, from 522 to 542 miles below Cairo. Operations were begun in 1882 and actively prosecuted until 1885, and some repairs were made to these earlier works in 1886 and 1888-89. The Duncansby, Mayersville, Baleshed, and Stack Island systems of dikes were constructed on the Mississippi side of the channel and the Cottonwood and Elton systems on the Louisiana side, and bank revetment was constructed at Louisiana Bend and Mayersville Island. The total lengths of the various constructions were about at follows: 112,396 feet of pile dikes, 48,238 feet of foot mats between dikes, 16,547 feet of foot mats along the dikes, 5,588 feet of screens in front of the dikes, 13,561 feet of wattling between dikes, 520 feet of shore revetment at the ends of dikes, and 33,476 feet of bank revetment. See Annual Report of 1895, page 3843, for a tabular summary of the work. The details of these works are given in the Annual Reports of 1883, page 2285; 1884, page 2814, and 1885, pages 2748 and 2960. Maps accompany the reports of 1883, 1884, 1888, and 1889.

These earlier works had a beneficial effect on the channel, but they were comparatively weak and were lost, partly through lack of funds for their maintenance and Congressional limitation of the use of bank revetment. The Duncansby system was reported as practically destroyed by 1886, the Louisiana Bend revetment by 1887, and by 1889 only portions of the system at Baleshed Bar and Stack Island remained out of all the works that had been built. Parts of these are still in existence where not exposed to the destructive action of the river.

Louisiana Bend revetment (*522. R*).—In 1889 active work was resumed. It was decided to revet the caving bank near the head of the reach in Louisiana Bend, hoping thus to give greater permanence to the channel throughout the reach.

About 6,024 linear feet of revetment were built in 1889–90, 5,224 feet in 1891–92, and 5,835 feet in 1892–93, when further operations were suspended. The type of revetment used was much stronger than that formerly employed, consisting of woven mats below water 260 to 345 feet wide, and upper-bank paving of stone 10 inches thick. On account of the unstable nature of the bank along the mouth of Old River it was necessary to make some repairs each year to the upper-bank paving, where sloughs occurred during low-water stages, and in 1892 and 1893 seven short spur dikes of brush and stone were built on the upper bank, where the high waters caused scouring behind the revetment. Breaks in the revetment were repaired in 1896–97 by the construction of about 1,247 linear feet of new revetment, using fascine mats. The details of these operations are given in the Annual Reports of 1890, page 3229; 1892, page 3177; 1893, page 3754; 1894, page 2921; 1895, page 3806; 1896, page 3653, and 1897, page 3727. Maps accompany the reports of 1890, 1892, 1893, and 1896.

This work has been carried away from ranges 136 to 168 (the lower end of the work) and breaks have occurred between ranges 127 and 136. In view of the small amount of available funds and the difficulty that had been experienced in holding this part of the bank, it was decided to abandon this work for the present.

No work of construction has been done here during the year and none is recommended. The original length of this revetment, including the portion lost, as mentioned above, is about 15,820 feet, measured along the shore edge of mats.

Lake Providence revetment (*540 R.*).—This revetment was built to hold a rapidly caving bank that threatened to destroy the town of Lake Providence and the important levee across the foot of the lake. About 4,780 linear feet of revetment were built in 1894–95, 5,360 feet in 1895–96, and repairs to upper-bank paving were made in 1898. In January, 1899, work was begun to extend the revetment a short distance up river, but after sinking two small mats the river rose and work was suspended. In 1899–1900 the revetment was extended up river 1,200 feet and two breaks repaired. In 1900–1901 the revetment was extended up river 1,800 feet, and existing breaks and several that occurred during the progress of the work were repaired. In the fall of 1901 the dredge *Gamma* made a cut along the upper side of the Stack Island bar, with a view to relieving the congestion of the water at this point and reducing the strain on the revetment. The details of the work are given in the Annual Reports of 1895, page 3806; 1896, page 3653; 1898, page 3372; 1899, page 3540; 1900, page 4826; 1901 (Sup.), page 268, and 1902 (Sup.), page 110. Maps of the work accompany the reports of 1896, 1900, 1901, and 1902.

During the past year two small breaks between ranges 95 and 98 and between ranges 103 and 108 have been repaired. For details of the season's work see accompanying reports of Mr. Arthur Hider and Mr. George C. Thomas.

A small break occurred in this revetment in the latter part of January, 1903, from about range 78 to 80, caused by a strong eddy current which developed at this point. When last seen this break gave no indication of further extension, but will have to be repaired during the coming season.

The length of this revetment work is about 12,800 feet, and is apparently in good shape except the break above mentioned.

A survey made in October, 1902, extending from Homochitto to Lake Providence (see accompanying map), showed a decided change in the bar lines on the upper side of Stack Island bar and the lower side of Benham bar, the former having receded and the latter having built down and out. This has very much relieved the revetment at the upper end, but a considerable narrowing of the channel farther down still throws a great strain on the revetment at a lower point.

It is believed that the situation at this point is gradually improving, but that the revetment at ranges below 80 will still be subjected to excessive strain as the point of engorgement moves down, and that repairs will be needed to this portion of the work for some years. There is a possible relief, however, in another direction, as the high part of the Stack Island bar at the upper end has been cut away, allowing a portion of the river, at a moderate stage, to pass through the middle of the bar, and indications, when last seen, showed that above a 20-foot stage a considerable flow had passed through this channel.

The developments on the recession of this flood and the result of the survey of this reach, which should be made during the coming summer, will be watched with considerable interest.

The total expenditures for the year have been $19,793.68, and for the whole reach from the beginning of the work, $3,788,926.29. The total expenditures for Lake Providence revetment alone have been about $403,777.63.

DELTA POINT (598 MILES BELOW CAIRO).

The cut-off that occurred at Vicksburg in 1876, and the subsequent shoaling of the channel leading from the river to the resulting lake front of the city, practically destroyed the harbor at Vicksburg for low-water commerce.

The first operations undertaken for the improvement of the harbor consisted in revetting the rapidly caving bank at Delta Point, as its continued recession was increasing the distance from the harbor proper to the channel of the river. From 1878 to 1881, before the Mississippi River Commission assumed charge of the work, there were built about 5,400 linear feet of revetment, one mattress spur dike, and two screen dikes, at a total cost of $203,229.87. The details of the work for this earlier period are found in the Annual Reports of 1878, page 637; 1879, page 974; 1880, page 1333; 1881, page 1384, and 1882, page 1502.

The river and harbor act of August 2, 1882, placed this work under the supervision of the Mississippi River Commission. The work of revetment at Delta Point was continued, 1,100 linear feet of revetment being built in the season of 1882–83, 2,200 feet in 1883–84, 2,083 feet in 1884–85, 1,065 feet in 1893–94, and repairs to upper bank paving were made in 1898. On account of unfavorable season for work the project for 1898 was not carried out but left to go over to 1899. Practically all the work prior to 1882 is destroyed or covered by the later work. Only the mats of 1893–94 had the present standard width of 300 feet, the earlier ones being from 150 to 175 feet wide. Extensive repairs were made in 1899–1900. Details of the work under the Commission are given in the Annual Reports of 1883, page 2290; 1884, page 2820; 1885, pages 2787 and 2964; 1889, page 2709; 1893, page 3754; 1894, page 2921; 1898, page 3373, and 1900, page 4827. Maps accompany the reports of 1883, 1884, 1888, 1889, 1893, and 1900.

No work has been done during the past year.

During the past season some caving has occurred above the work, but the upper end of the revetment is protected by a hard point and there is no immediate danger of the work being flanked. As the levee is some distance back from the bank no serious trouble can result from the caving.

In considering this work heretofore it has been thought that the caving above the head of the existing work would in a certain measure relieve the strain on the revetment, throwing the current away from the same and toward the Mississippi side of the river. With respect to the work under the Commission, this would undoubtedly be an advantage, but the modified project for the improvement of Vicksburg Harbor under the Engineer Department calls for the construction of a large and expensive levee from the mouth of the canal along the bank of the Mississippi River toward Kings Point, with scarcely any other location possible. For this reason it is considered that for the general good of Government work the Mississippi side of the bend must not be allowed, if possible to prevent, to become a caving bank. It is considered advisable, therefore, that the caving above the existing work be carefully watched, and if the bend deepens sufficiently to throw the current toward the other shore, steps be taken to extend the Delta Point revetment upstream, as it is believed that the more stable bank and the probable less extensive work will render it more economical to save Vicksburg Harbor by extending Delta Point revetment upstream. Aside from this, the levee referred to will be so near the bank that it is doubtful whether a revetment could be built if the bank should begin caving.

The improvement of Vicksburg Harbor proper is now in charge of the Engineer Department in accordance with the project adopted by the river and harbor act of July 13, 1892, providing for the diversion of the Yazoo River into Centennial Lake. A summary of the work done in the harbor by the Mississippi River Commission is given in the Annual Report of 1897, page 3728.

The total amount expended under the Mississippi River Commission has been $442,724.75 in Vicksburg Harbor, and $186,256.21 at Delta Point, making the total expenditures at the latter point $389,486.08.

LOWER YAZOO LEVEE DISTRICT (365 TO 592 MILES L. BELOW CAIRO).

This district extends in Mississippi from the Coahoma-Bolivar County line to the mouth of the Yazoo River, being practically coterminous with the local Mississippi levee district.

The levee line is continuous from the upper end of the district to Kigers on Eagle Lake. Its length is about 188.34 miles, covering about 220 miles of the river.

During the past year there have been constructed by the United States 1,004,258 cubic yards, and by the local levee board 482,391 cubic yards. A large portion of the revenues of the local levee board is expended for rights of way and damages to property affected by levee work. The net contents of the line May 1, 1903, are about 33,263,691 cubic yards. The United States have built altogether about 17,440,625 cubic yards. No figures are available showing what portion of the existing line has been built by the United States. Tabular statements of expenditures and work done by the United States accompany this report.

The work undertaken by the United States during the year has consisted of the construction of two new loops, one at Jenkins and the other at Duvalls; one piece of banquette, and the enlargement of several sections which were below the provisional grade (3 feet above high water of 1897), amounting to 1,375,000 cubic yards, which were let at the average price of 18.9 cents per cubic yard.

Weed cutting has been done throughout the entire district by the United States.

Practically all of the work necessary to bring the whole line to the provisional grade (3 feet above high water of 1897) is now under contract. The total yardage necessary to bring the whole district to the ultimate grade, which is practically 6 feet above high water of 1897, is 14,485,408, including new loops which will be needed.

On February 12 bids were opened for levee work for the year ending June 30, 1904, when 1,370,000 cubic yards were let at an average price of 15.026 cents per cubic yard.

High-water operations in both districts will be considered together.

For additional details of work in this district see report of Mr. A. Miller Todd, appended.

The expenditures for construction and maintenance of levees during the past year in the lower Yazoo district made by the United States have been $166,923.70, and the total expenditures in this district $3,081,669.99.

UPPER TENSAS LEVEE DISTRICT (402 TO 606 MILES R. BELOW CAIRO).

This district extends from the Arkansas River to a point in Louisiana opposite Warrenton, Miss. There is a continuous levee line about 171.65 miles long, extending from Costello's gin on Amos Bayou, along that bayou and Cypress Creek to the Mississippi River, and thence along the river to the lower end of the district.

The district is protected from overflow of the Arkansas River by a levee line along that river from the vicinity of Pine Bluff to a point below Lake Jefferson. From Pine Bluff to Redfork (57.3 miles) this line is of comparatively weak section, built and hitherto maintained by the local authorities. From Redfork to the foot of Lake Jefferson and thence toward the junction of Cypress Creek and Boggy Bayou (14.85 miles in all) the levee has been built principally by the United States. The total length of levee under the jurisdiction of the United States in this district is 186.7 miles.

During the past year there have been added to the line by the United States about 269,563 cubic yards and by the local authorities about 453,587 cubic yards. The yardage thrown out by the construction of a new loop in Louisiana was about 210,000 cubic yards, thus giving total contents of levees May 1, 1903, about 29,092,868 cubic yards. The United States have put in altogether in this district about 21,956,421 cubic yards. No figures are available showing what portion of the present line has been built by the United States. Tabular statements of expenditures and work done by the United States accompany this report.

It is estimated that it will require about 3,169,045 cubic yards to bring the levees in this district to the provisional grade of 3 feet above the high water of 1897 with standard section, including a necessary loop at Mascot, and to close the gap between the Arkansas River system and the Mississippi River system to the same grade 1,340,716 cubic yards, and 18,642,738 cubic yards to raise the present line to the ultimate grade adopted by the Commission, which averages about 5.5 feet above the high water of 1897, including two new loops, amounting to 1,701,732 cubic yards, the construction of which will be necessary before this increase in grade can be made. To close the gap between the Arkansas River and the Mississippi River systems to the ultimate grade will require 1,609,105 cubic yards.

About 411,000 cubic yards of work have been undertaken in this district during the year, all of which was enlargement, at an average price of 19.086 cents per cubic yard, and with one exception the contracts are nearly completed.

On February 12 bids were opened for levee work for the year ending June 30, 1904, when 479,800 cubic yards were let at an average price of 17.073 cents per cubic yard.

High-water operations will be considered below.

For additional details of work in this district see report of Mr. E. C. Tollinger, appended.

The expenditures by the United States during the past year for levees in this district have been $67,259.59, and the total expenditures by the United States have been $4,341,858.01.

HIGH-WATER OPERATIONS.

Some time before the river reached the flood stage the engineer officer in charge was taken ill, and beyond giving a few general directions as to the portion of the work to be undertaken by the United States, he was in no way connected with these operations.

The policy adopted from the start was to limit the Government operations to furnishing and operating steamboats, and furnishing barges and quarterboats, and to leave all payments for material and labor other than boat service to local levee boards. This plan was strictly adhered to, except in a few cases where small accounts were paid by the United States.

On March 4 a letter was written placing all high-water operations under the charge of Mr. Arthur Hider, assistant engineer. For details of this work see reports of Mr. Arthur Hider, Mr. E. C. Tollinger, and Mr. A. Miller Todd, assistant engineers, appended.

The following table, showing the high-water slope of 1903 relative to those of 1897 and 1898, is taken from the report of Mr. A. Miller Todd:

Station.	Miles below Cairo.	Locality.	Above 1897 high water.	Above 1898 high water.	Remarks.
			Feet.	*Feet.*	
240	370 L.	Australia	1.2	2.2	
860	378 L.	Gunnison	1.5	2.5	
1500	398 L.	Rosedale	1.5	2.7	
1810	402 L.	Beulah	1.2	2.5	
2600	417 L.	Bolivar	.7	2.4	
3030	433 L.	Eutaw Landing	.1	1.8	
3400	439 L.	Arkansas City gauge	1.2	1.9	Opposite station 3400.
3600	457 L.	Bolivar-Washington county line.	3.1	4.1	Just below end of Huntington Short Line.
3675	458 L.	Mound Bayou	1.4	2.4	
3882	461 L.	Carters Neck	1.1	2.2	
4270	478 L.	Greenville gauge	2.4	3	
1500	502 L.	Longwood	2.8	2.6	
2000	513 L.	Leota	2.3	2.3	
2900	533 L.	Mayersville	2.5	2.7	
3400	542 L.	Lake Providence gauge	2	2.2	Opposite station 3400.
4000	555 L.	Fitlers	2.6	2.4	
4800	568 L.	Duvall	2.6	2.8	
5200	573 L.	Brunswick	3	3	

The high-water slope throughout the district appears, with the exception of a stretch of river from Bolivar to Greenville, to be very nearly parallel with the high-water slope of 1898, and its divergence from the high-water slope of 1897 ranged from 1.5 feet above in the upper part of the district to 2.5 feet above in the lower part, and is probably due to the higher stages in the Arkansas and White rivers tending to increase the height of the recent flood below these rivers, and to the lowering effect in the lower part due to the crevasses which occurred there in 1897. This is borne out by the fact that the difference in level between the flood of 1903 and that of 1898 (when no breaks occurred) was about the same in both the upper and lower part of the district.

The abnormal departure from parallelism with the floods of 1897 and 1898 occurs between Bolivar and Greenville, and it is believed that this departure can be explained by the change in conditions at Huntington and Leland. The river was formerly contracted at Arkansas City by the levees. The construction of the Huntington Short Line and the opening up of a waterway across this point had the effect of the removal of a dam, drawing down the water plane from Bolivar to the upper part of the Huntington Short Line and causing a remarkable rise in the water plane at the lower end of this line.

By the time that this abnormal rise in the water plane had lost its effect the river is believed to have come under the influence of the excessive draw across Leland Neck, caused by the loss of an old levee, which had in former high waters acted as a spur to prevent this flow. This is indicated by the gauge at Carters Neck, which shows a less difference from former high waters than those above Bolivar and very much less than those from Greenville down.

It is believed that this effect is entirely similar to that at Huntington, drawing down the water plane above and raising that below, but in a much less marked degree.

It is believed that had these two points (Huntington and Leland) been in the same condition that they were in 1898, the plane of the water of 1903 would have been practically parallel to that of 1898, but about 2.5 feet higher throughout the district. Compared with 1897 it would have been parallel and about 1.5 feet higher down to the mouths of the Arkansas and White rivers; then diverging to about 2.5 feet higher in the vicinity of Greenville; thence remaining at about that difference to the lower end of the Yazoo district.

It is believed to be plainly shown that whenever the river has been abnormally gorged by proximity of the levees on the two sides and is afterwards widened a considerable increase in the height of the levees must be provided for for some distance below. It is thought that the grade of the levees throughout the district as far down as Brunswick should be practically parallel to the high water of the season, as full Arkansas and White rivers must be provided against.

It is probable, however, that a slight excess over the height reached by the water will have to be provided for between Greenville and the lower end of the Yazoo district, as the effect of the Lagrange crevasse was to cause no further rise in the river from Greenville to Vicksburg.

It is not practicable at the present time to make a definite statement as to the future grade from Henderson to the lower end of the Upper Tensas district, as this portion of the levee was more or less affected by the return water from the Lagrange crevasse through the Yazoo River. The flood of 1903 along this portion of the levee was generally below that of 1897.

SURVEYS, GAUGES, AND OBSERVATIONS.

The regular surveys of the bank revetments, the caving bends at Carters and Calks necks, and the survey of Lake Providence Reach from Homochitto to Lake Providence were made during the year.

The expenditures during the year have been $4,023.99, and under this allotment have been to date $86,944.09.

STONE.

Stone for the work during the season was obtained from a small reserve supply on hand which was quarried at the Government quarry on Little Red River and towed to Greenville during the spring of 1901, and by contract at the rate of $1.73 per cubic yard on the bank and $1.92 per cubic yard on Government barges at Greenville.

The Government quarry on Little Red River was opened in January, and stone quarried, loaded, and towed to Greenville as long as the stage of that river would permit, with the exception of two delays, one caused by an intervening stage too low for towing and the other by the withdrawal of the towboat for use in high-water operations.

The amount of stone quarried and loaded on barges and towed to Greenville during the season was 12,300 cubic yards, and about 400 cubic yards remained at the quarry. The cost of quarrying this stone was 50.62 cents, and cost of loading 30.53 cents per cubic yard. The cost of towing was 66.4 cents per cubic yard, and the cost of unloading at Greenville 16.4 cents per cubic yard. This makes the stone cost on the bank at Greenville $1.639, effecting a saving over the contract price for this year of 9 cents per cubic yard.

Besides this saving in cost the stone obtained from the Government quarry is vastly superior to that furnished by contract, resulting in much less labor to place and a very superior pavement, the blocks being of regular size and shape. In addition to this there is a very great advantage in having the supply of stone on hand when the season's work begins, thus avoiding expensive delays due to the failure of contractors to begin delivery promptly or to deliver at a proper rate.

The expenditures during the year have been $16,959.82, and under the allotment $251,164.62.

GENERAL REPAIRS TO EXISTING WORKS.

The allotment under this head was $50,000 and there remains at the present time $21,194.55.

The expendures from this allotment were made at Lake Bolivar Front, Ashbrook Neck, and Lake Providence and have been accounted for in the statements of expenditures for these points.

PLANT.

Repairs to plant were made during the year as shown in the detailed statement accompanying the report of Mr. Hider. The cost of repairs amounted to $10,088.15, and the cost of caring for the floating plant and other property amounted to $22,261.54. Of this, $446.63 was taken from other allotments.

The total expenditures under this allotment have been $834,557.19.

The following papers and maps accompany this report:

Appendex 3 A, report of Mr. Arthur Hider on surveys, revetment work, stone, plant, and high-water operations, with report of Mr. George C. Thomas appended.

Appendix 3 B, report of Mr. A. Miller Todd on levees in Lower Yazoo district.

Appendix 3 C, report of Mr. E. C. Tollinger on levees in Upper Tensas district.

Table showing cost of work done by the United States on levees.

Map of Third district.

Map of a part of Lake Providence Reach.

Map showing extent of overflow.

Profile showing high-water slopes (three sheets).

Levee sections proposed by Mr. Arthur Hider.

The list of civilian engineers, abstracts of proposals, list of contracts in force, and financial statements will be forwarded on or about July 1.

Very respectfully, your obedient servant,

Chas. L. Potter,
Captain, Corps of Engineers.

Col. O. H. Ernst,
Corps of Engineers, U. S. Army,
President Mississippi River Commission.

Appendix 3 A.

REPORT OF MR. ARTHUR HIDER, ASSISTANT ENGINEER.

Greenville, Miss., *May 9, 1903.*

Sir: I have the honor to submit the following report of surveys, construction work, repairs to plant and care of same, from May 1, 1902, to May 1, 1903.

SURVEYS.

The steamer *Meter* and survey boat left Greenville on September 2 with a survey party in charge of Luther Y. Kerr, junior engineer, to make the annual surveys over the different revetments to determine their condition. The fieldwork was completed and the outfit returned to Greenville October 28, and the field party disbanded the next day.

The following surveys were made: Shore-line surveys on the upper side of Caulk's and Carter's necks; hydrographic surveys over the revetments at Lake Bolivar, Ashbrook Neck, Greenville Harbor, Louisiana Bend, Lake Providence, and Delta Point. A survey was also made over part of the river in Lake Providence Reach extending from Homochitto, Miss., to Lake Providence, La., to determine what changes had taken place in the upper part of the Stack Island bar, where dredging had been done the previous season.

An extract from the report of Mr. Kerr is given below, showing a comparison with the surveys of 1901, no revetment surveys having been made last season:

"CONDITION OF REVETMENTS.

"*Lake Bolivar revetment* (*417 L.*).—The sections show a slight fill over the outer work, except from ranges 30+15 to 5+55, where there is a slight scour, ranging from 1 to 5 feet. There are some places along the upper slope, where the paving was done on a steep slope, that the stone has been washed away and the bank more or less cut by the wave action. No change in the shore line.

"*Ashbrook Neck* (*446 L.*).—This work, taken as a whole, is in a remarkably fine condition. Beginning at the upper end and coming down the line there is no change of consequence until we reach range 101. Ranges 101, 99, and 97 show the scour on the shore end of the section that cause a slough in the upper slope between ranges 99 and 97. This, however, does not affect the mattress work.

"The next and last change of section is on ranges 27 and 29, where considerable scour has occurred, causing a slough in the bank about 200 feet in length extending up about 20 feet above the zero of the gauge. The maximum caving is about 300 feet above the work, where it amounts to about 150 feet for the past two years.

"No material change was found in shore line below the work. The bar line has moved out 200 feet opposite range 95 and back 200 feet opposite the lower end of the work.

"*Greenville Harbor revetment* (*478 L.*).—Beginning at the upper end, there has been considerable scour on ranges 94 to 103, both in front and behind the dike formed by the inner edge of the mattress extending up and out from range 104, the dike remaining about the same. From ranges 104 to 108 there has been a very heavy scour, with a maximum of 32 feet on range 104, causing a sinking of the mattress work and a sloughing of the bank. From range 109 to range 57 there has been no change in the past two years. The changes on the upper slope of ranges 34 and 35, which are included in the last stretch, are due to grading in repairing breaks. Ranges 58, 59, and 60 show considerable scour on the shore end of the section. This, however, is only a removing of a former deposit. No change from ranges 60 to 76.

"At the upper end the bar line continues to crowd over toward the bend, where about the usual amount of caving has taken place.

"*Louisiana Bend revetment* (*522 R.*).—The sections over this work show a continuous and rapid filling in the upper part of the reach, particularly on the outer end of the section, where the filling has taken the form of a middle bar. This continues on the outer end of the section throughout the reach, decreasing as it extends down the river. At range 136 a scour appears on the shore end of the section and continues to range 168, the lower end of the work. This scour is back of the original revetment, all the upper slope work having been destroyed by caving. The shore line at range 168 is now about 600 feet back of the original position of the revetment. On the lower end the bar continues to move out and the main bank continues to cave, while at the upper end a bar is making down on the Louisiana side and forcing the Mississippi bar back.

"*Lake Providence revetment* (*517 R.*).—Beginning at the lower end there is practically no change from ranges 0 to 14. On range 16 a slight scour makes it appearance on the outer end of the section and increases in depth up the river to range 36, where a scour of 30 feet is shown at the outer edge of the mattress. From ranges 37 to 60 the scour is generally beyond the mattress; from 62 to 82 it has been very general and heavy, amounting to 35 feet on range 96. Range 98 has deepened throughout the entire section from 20 to 30 feet. The unstable condition of the bank, due to the heavy cutting on ranges 96 and 98, is shown by the fact that a slough about 100 feet wide has occurred about midway between the two ranges.

"A scour of about 30 feet is shown on range 100. This, however, is all beyond the outer edge of the mattress. On ranges 102 to 110, inclusive, the tendency is to deepen the section, but no very great change has taken place. Ranges 112, 114, and 116 have deepened considerably under the mattress; range 112 dangerously so. On ranges 118 to 140 the sections are filling rapidly. The bar line has moved back on ranges 104 to 132 and out on ranges 20 to 104. No change in shore line except on ranges 80 to 98 and from ranges 118 to 122, where it has, in both instances, been graded off since the former survey.

"*Delta Point revetment* (*598 R.*).—Beginning with range A at the lower end, there is no change in section up to and including range 16; from ranges 14 to 4 east there is considerable fill on the outer end of the section, range 8 showing a fill over the entire section; from range 2 east to range 11 west there is no change; ranges 13 and 15 show considerable scour on the inner half of the section; from ranges 17 to 27 the deep water is moving shoreward and causing a general sloughing of the bank.

"*A part of the Lake Providence Reach* (*536–542 R.*).—The sections over the reach from Homochitto to Lake Providence show that the zero of the Longwood bar has moved down about 3,000 feet and that the Louisiana end of the sections, from ranges 11 to 15, has built up very considerably.

"On the Mississippi side the zero line of the bar has moved back 500, 700, 1,200, 1,100, 950, 800, 500, and 200 feet on ranges 11, 12, 13, 13½, 14, 14½, 15, and 15½, respectively, crossing out betweeen ranges 15½ and 16, causing considerable scour along the revetment on ranges 16 to 19, inclusive.

"*Caulk's and Carter's necks* (*410–425*).—The shore line survey on the upper side of Caulks Neck shows a maximum caving of about 300 feet in the past two years. The caving on the upper side of Carters Neck has been very slight."

The following maps and sections have been plotted:

- 1 index map and 3 sheets of sections, Lake Bolivar front.
- 1 index map and 5 sheets of sections, Ashbrook Neck.
- 1 index map and 11 sheets of sections, Greenville Harbor.
- 1 index map and 5 sheets of sections, Louisiana Bend.
- 1 index map and 6 sheets of sections, Lake Providence.
- 1 index map and 4 sheets of sections, Delta Point.
- 1 map, Caulks Neck.
- 1 map, Carters Neck.
- 1 map, Lake Providence Reach (1″=10,000′).
- 1 map, Lake Providence Reach (1″=400′).

Total, 10 maps and 34 sheets of sections.

The cost of making the above surveys is as follows:

Pay roll	$2,404.82
Subsistence	487.29
Material	363.98
Total cost	3,256.09

REPAIRS TO REVETMENTS.

At the beginning of the season the project was to repair the break which had developed near the head of the Greenville revetment, extend the revetment upstream at the upper end of the Ashbrook Neck work, to check the eddy that had formed and was threatening the stability of the work at that point, then to continue the work of the previous season in reenforcing the revetment at Ashbrook Neck with fascine mats 250 feet wide, and repair the upper bank slope at Lake Bolivar by regrading and repaving.

The complete carrying out of this plan was interfered with on account of a break in the revetment that occurred above Lake Providence while the work at Ashbrook Neck was in progress. It was necessary to move the party there, after one of the reenforcing mats had been sunk in place, to make the necessary repairs.

But one revetment party was in the field. This party completed the mattress work, bank grading, and such paving as could be economically done, leaving the upper part of the slope paving to be finished by a small party organized for this purpose, at a more favorable stage of water. By this arrangement one set of mat barges was found to be sufficient for the three works. As soon as the mat work was completed at one point the party was transferred to another place. This saved time and allowed the full capacity of the mat boats to be utilized.

Repair work of this kind is necessarily expensive on account of the cost of transportation and organization and the small amount of work at each place.

So far as known the revetments are in fair condition, the only known defect existing being a small break in the Lake Providence revetment at ranges 78 to 81, extending about 100 feet behind the revetment. This was caused by eddy action. The break occurred too late in the season to be repaired.

The amount and cost of these repairs are given in the accompanying report of Mr. George C. Thomas, superintendent, who had charge of the party.

QUARRYING STONE.

Operations were begun January 12 under Supt. George C. Thomas, and on the 15th the first tow of empties arrived at the quarry. Loading was begun on the 17th from the reserve, but was discontinued on the 19th on account of low stage of water. It was resumed on the 28th and was continued, except twenty-two days while the towboat was withdrawn for high-water service, until low water in the Little Red River caused an indefinite suspension.

The quarrying of stone and cleaning up of the quarry from the accumulations of several years of former work has been carried on continuously from the beginning. A large quantity of spawls, earth, and trash had accumulated, which it was necessary to remove to put the quarry in good working shape. The cost of this cleaning and putting the quarry into proper condition for economical work was $2,098.33. This is included in the cost of quarrying stone in the statement given below and averages 17.06 cents per cubic yard.

The quantity of stone quarried and loaded on barges during the season was 12,300 cubic yards, at a cost of $9,981.41. In addition there has been quarried ready to load approximately 400 yards. No credit is taken for this in the statement.

Twelve to fifteen thousand cubic yards in one season may be considered the maximum quantity of stone that can be economically obtained from this quarry with a favorable season for towing. Some seasons little or no stone can be towed out on account of lack of water in Little Red River.

Average cost per cubic yard of quarrying stone for season.

	Cents.
Cleaning up quarry	17.06
Drilling	7.56
Blasting	3.07
Breaking	21.61
Miscellaneous charges	1.32
Total	50.62

The average cost of loading on barges at the quarry was 30.53 cents per cubic yard.

Sufficient local labor could not be procured for the work and it was found necessary to import a number of men. The wages paid ordinary labor was $1 per day, including subsistence; drillers and stone breakers, $1.20 per day, including subsistence; teams, including drivers, $2.50 per day, without subsistence. The average force of men employed was 50.

In order to operate the quarry economically and to take advantage of the short period that the water is at a sufficiently high stage for towing, it is recommended that all work for stripping needed for the coming season's work be done and that enough stone be quarried in advance to fill the floor of the quarry so that loading can be begun as soon as there is water.

TOWING STONE.

Towing was done by the steamer *Arthur Hider*, generally with a double crew. It was found that the boat had ample towing capacity, using 18 barges, 6 at the quarry, 6 en route, and 6 being unloaded at Greenville, to tow all the stone that could be quarried, even with the interruptions due to low water and demands for other work.

The boat was put in this service January 12, having been withdrawn eight days in January on account of low water and twenty-six days in March and April while the boat was employed on levee protection during the high water. The number of days actually engaged in towing was one hundred and eight.

At the close of the season, on account of the sudden drop in the stage of the river at the quarry, 6 barges, 4 of these loaded, were caught above the shoals just below the quarry and 6 empty barges ready to load were towed below the shoals and left awaiting a rise. It is expected that the next rise will give sufficient water to load a part of these empties, if not all, and enable the loaded barges to be got out. This work will in all probability end the season's towing.

The cost of stone from this quarry the present season, loaded on barges ready for use, including unloading at Greenville and reloading, will average about $1.75 per cubic yard. The present contract for Alabama stone delivered by rail is $1.92 per cubic yard loaded on barges. This stone is much more desirable than the Alabama stone for revetment purposes on account of its shape, which allows more ground to be covered by the same quantity and its greater specific gravity, which is also an advantage.

Procuring stone from this quarry insures a reserve on hand with which to begin work, and to a great extent makes the progress of the work independent of the rail delivery, which has always been behind at this season of the year on account of claimed lack of transportation facilities due to scarcity of cars.

The only drawback is the limited output of the quarry and the uncertainty of boating stage. Some seasons practically no stone can be towed out on account of the low stage in Little Red River.

Below is given the cost of the different items of the season's work:

Date.	Loaded.	Towed.	Unloaded.	Cost on barges	Cost of towing.	Cost of unloading.	Total.
	Cu. yds.	*Cu. yds.*	*Cu. yds.*				
January	1,700	None.	None.	$1,487.82	$1,491.55	None.	$2,979.37
February	3,646	3,986	2,224	2,141.58	2,088.52	$430.77	4,660.87
March	2,976	2,069	3,397	3,483.82	1,004.72	469.67	4,958.21
April	3,977	4,352	2,555	2,868.19	2,324.20	442.02	5,634.41
Total	12,300	10,407	8,176	9,981.41	6,908.99	1,342.46	18,232.86

	Per cubic yard.
Average cost on barges at quarry	$0.811
Average cost of towing	.664
Average cost of unloading	.164
Cost on bank at Greenville	1.639

Cost of towing, previous seasons, is as follows:

	Per cubic yard.
1893	$0.655
1894	.6425
1895	1.96
1897	.859
1901	.617
1903	.664

PLANT.

The amount expended in repairs to plant during the year was $10,088.15. These repairs were confined to necessary work to the steamboats to keep them in working order, and such repairs as were absolutely necessary to render the quarterboats, hydraulic grader, mattress barges, mooring boats and material barges fit for service for revetment purposes for the season's work.

During the year 1900-1901 the expenditure made for this purpose was $34,697.56; in 1901-2, $6.311.51, and for the present year $10,088.15.

A careful examination of the condition of the entire working plant and an estimate in detail has been made of the cost of repairs required for each boat and barge, a summary of which is given below.

As will be seen from the figures given above, no extensive repairs have been made since 1901, and in order to keep the plant in working condition a large amount of repairs will be required the present season. The following is the estimated cost of repairs for 1903-4:

12 quarterboats (2 office boats, 1 survey boat, 7 laborers' quarterboats, 1 dining boat, and 1 sleeping boat at fleet)	$14,500
Ordinary repairs to steamboats during year	2,500
2 small line barges	1,000
12 material barges, first class	700
6 material barges, second class	600
8 material barges, third class, sheathing	3,200
1 hydraulic grader	500
2 mat boats	750
2 mooring barges	2,100
1 loading barge	400
1 machine and 1 carpenter shop	3,750
Total	30,000

This amount expended for repairs on the present plant will put it in fair condition, so that for the next two or three years the annual cost of repairs will be materially reduced.

With the towboat now under contract and the twelve material barges which are to be built this district will have sufficient plant, with the addition of a set of mattress barges, to operate two revetment parties.

The hull of the tug *Parker* is rotten and in bad condition generally and should be rebuilt within the next year. Plans are being prepared for a steel hull to replace the old wooden one.

Cost of repairs to plant, Third district, improving Mississippi River, May 1, 190, to May 1, 1903.

Number or name.	Cost.	Remarks.
Steamer—		
Arthur Hider	$1,010.02	General repairs.
Vedette	1,140.23	Do.
Meter	426.61	Do.
Tug Parker	729.68	Do.
14 quarterboats	1,538.35	Do.
8 mattress boats	216.42	Do.
Carpenter shop No. 78	115.56	Do.
Machine shop No. 222	151.76	Do.
Store boat No. 138	50.83	Do.
32 barges	2,405.45	Do.
Grader No. 1	209.73	Do.
Grader No. 77	1.92	Minor repairs.
Pile driver No. 49	30.64	Roof repaired.
Floating dry dock	280.51	Sides calked and sheathed.
Skiffs	24.64	Minor repairs.
Pumps	463.23	35 made and old ones repaired.
Construction	521.69	Repairs to tools, skiffs, and wheelbarrows.
Surveys	60.89	Making stadia boards and stakes; repairing skiffs.
Property	99.25	Repairs to kitchen ware and tools.
Miscellaneous	610.74	Making cable clamps, etc.
Total	10,088.15	

Approximate value of plant belonging to the United States and used in the Third district, improving Mississippi River, May 1, 1902, to May 1, 1903.

Class of property.	Number.	Approximate value.
Steamer Arthur Hider, with outfit	1	$32,11
Steamer Vedette	1	2,00
Steamer Meter	1	1,50
Tug Parker	1	1,50
Mat boats 26, 27, and 188 (old)	8	2,00
Mat boats 28 and 29 (new)	2	5,00
Headquarter boat No. 31	1	2,50
Quarter boats	11	7,00
Quarter boat No. 154 (in use by Mississippi River Commission, condition not known)	1	....
Barges (square)	38	32,00
Pile driver No. 49	1	1,00
Store boat No. 138	1	20
Grader No. 1	1	5,00
Grader No. 3 (in use by Fourth district, condition not known)	1	....
Grader No. 77	1	1,00
Floating dry dock	1	5,00
Stern dock	1	....
Skiffs	8	10
Boats, calking	3	60
Carpenter shop and outfit	1	2,00
Machine shop and outfit	1	2,70
Office furniture	....	225
Surveying instruments	....	1,20
Total	78	104,096

The cost of caring for the above plant and property was $22,261.54.

The average number of men engaged in the service of care of and repairs to plant was 34.

The average daily cost for subsistence of employees engaged in care of and repairs to plant was 35.2 cents.

HIGH-WATER OPERATIONS.

Immediately after assuming charge of high-water operations, as directed in your instructions of March 4, a consultation was had with the assistant engineers in local charge of the levees and the presidents and engineers of the different levee boards in regard to the situation.

As it was deemed advisable to begin preparations at once, on March 9 the steamer *Vedette* began the distribution of sacks and tools and such barges as were in condition for service at the different points along the line on both sides of the river where work would probably be needed first. While this was being done all barges that could be repaired at small expense were made ready for service, so as to be prepared to fill all demands in case of emergency.

It soon became apparent that an unusual high stage of water would be reached and that there would be a call for every available barge, quarterboat, and steamboat belonging to the district for this service.

The towboat *Arthur Hider* was withdrawn from towing stone on March 13 upon her arrival from the Little Red River quarry, and used in high-water service until April 8, when towing stone was resumed.

The steamer *Meter* was put in commission March 20 and remained in service until April 8.

The use of the snag boat *Florence*, belonging to the Vicksburg district, was obtained for the Fifth Louisiana levee board March 23 and the expenses paid by them until April 1. During the month of April this boat was in service for the Fifth Louisiana levee board, the expense being borne by the United States.

The snag boat *Columbia* and a small quarterboat, both belonging to the Vicksburg district, were put in high-water service March 13 to April 7.

The tug *Parker* was used for short trips in the vicinity of Greenville.

The steamer *Vedette* has been constantly in service since the beginning of high-water operations.

The general disposition made of these boats during the high-water operations was as follows:

Steamboats.—The *Vedette* in service on the left bank at the lower end of the district.

The *Meter* on the right bank along the Arkansas front.

The *Columbia* and *Florence* on the right bank along the Louisiana front.

The *Arthur Hider* in general service over the entire district.

In addition to these boats the Mississippi levee board chartered a small steamer, which was used exclusively in towing material for raising the levee below Huntington. Even with these towing facilities the different levee boards found it necessary in emergencies to have a considerable quantity of lumber and sacks delivered by local packets.

Quarter boats.—The first demand for quarter boats was at Vaucluse, Ark. Two quarter boats were delivered there March 10. The defect in the levee at this point having been remedied, they were moved to the lower side of Leland Neck March 17 and were kept in service at that point until the close of operations.

A small quarter boat was delivered at Lucca Landing March 13 for use of guards on the levee between Lucca Landing and Boggy Bayou.

On March 13 a small quarter boat belonging to the Vicksburg district was delivered at Rose Hill, La.

One quarter boat was delivered at Huntington on March 12, at the beginning of the work there. This not affording sufficient quarters for the large number of men employed, was supplemented by a second quarter boat March 15.

On March 15 one quarter boat was delivered at Lake Providence, La., and on the 17th a second quarter boat was delivered at the same point. These quarter boats were used first at Elton, La., next at Ashton, La., and afterwards moved to the Reid levee, below Vicksburg.

Barges.—Twenty barges were distributed at different points, as follows:

Protection of Mississippi levees:	
Parkers Landing	1
Mound Landing	2
Longwood Landing	1
Albemarle	1
Total	5
Protection of Arkansas levees:	
Lucca Landing	1
Gaines Landing	1
Upper Leland	2
Lower Leland	3
Lakeport	1
Grand Lake	1
Total	9

Protection of Louisiana levees:

Ashton	1
Pilchers Point	1
Lake Providence	1
Upper Wilton	1
Rose Hill	1
Delta	1
Total	6

Summary.—The following is a list of plant engaged in high-water operations:

	Steamboats.	Quarter boats.	Barges.
Protection of Mississippi levees	1	2	5
Protection of Arkansas levees	1	3	9
Protection of Louisiana levees	2	3	6
General service	1		
Total	5	8	20

All these boats were withdrawn from service and those belonging to third district returned to the fleet at Greenville after the crest of the rise had passed, except one towboat, which resumed the towing of stone, and two quarter boats and a barge, which were retained at the Reid levee at the request of the president of the fifth Louisiana levee board, to be available should the anticipated return flow through the Yazoo River from the Lagrange crevasse develop sufficient height to require work on the levees below Vicksburg.

Below is a statement of charges against high-water operations:

Pay roll	$4,629.32
Subsistence	1,391.29
Coal, oils, etc	2,158.68
Wire strand, etc	1,225.72
Rock	2,355.39
Sacks	6,500.00
Total expended	18,260.40

CREVASSES.

Three breaks, or crevasses, took place during the high water, one on the Albemarle front (568 L.) on March 27; another on the same day on the Lagrange front about 3 miles below Greenville (481½ L.), and the last on April 3, at Hollybrook plantation (547 R.).

The break at Albemarle was due to the water overtopping the levee. The levees in this, the lower end of the district, had not been brought up to as high a grade as those at the upper end, and as a result of the ground on the land side of the levee being submerged about 4 feet from backwater entering behind the levee system at the lower end, making it almost impracticable to get sufficient material to raise this long section of the levee line in advance of the rising river, the levee was breached by the water flowing over the top. The length of this break is reported as 1,100 feet.

The crevasse on the Lagrange front took place just before the crest of the rise had passed. The ends of the levee on both sides of the crevasse caved rapidly. The break occurred about 11 a. m., and before night it was over 1,200 feet wide, and more than one-half of Greenville was from 1 to 3 feet under water.

It was the intention of the levee board to at once make an effort to protect the ends of the levee so as to restrict the flow as much as possible. All preparations were made to this end. The necessary quarter boats, barges, etc., were got in readiness and a force of convicts brought from Huntington levee to begin work the next day, but at the solicitation of the city authorities and others the convict force was used in building a protection levee in Greenville and moving cotton. In the meantime the crevasse continued to widen rapidly at the upper end, until on the 30th it was about 3,900 feet wide. The force of convicts was then put at work building a sack dike to divert the current from the levee at the upper end. This work occupied about three days, and no further widening took place.

On April 17 the river fell sufficiently to render it feasible to make an attempt to shut off the greater part of, if not the entire flow. After consultation, the levee board decided to attempt the work, so as to have it completed in advance of the anticipated second rise, and thus reduce the damage caused by this crevasse to overflowed land to a minimum. This work was successfully accomplished by the 29th, the entire flow being cut off by that time.

Two steamboats, 5 quarter boats, 7 barges, 1 mattress boat, and 1 pile driver were furnished by the United States for this work, as well as 5,869 pounds of wire cable, 1,875 pounds of wire, and 350 pounds of spikes. Every facility was given the levee board in furnishing them plant and material and such experienced foremen as could be spared in order to make the work a success.

At Hollybrook crevasse a number of trees were felled in the woods in front of the crevasse, and brush dikes placed at each end of the broken levee to reduce the flow.

The details of the work done on the levees at the crevasses at Huntington, Leland, and other threatened points more properly comes under the head of levees, and will be found in the reports of the assistants having charge of this particular class of work.

CONDITION OF NECKS.

The surveys made last season indicated little change of any importance at either Caulks, Ashbrook, Carters, or Leland necks. As the water is still flowing across these necks it is impracticable now to make a careful examination and determine what changes have taken place during the past flood. Until such time as the river falls within its banks a careful survey can not be made. From surface indications, however, considerable change may be looked for in front of Huntington short line near the lower end, due to the rapid current along this levee at high water. This stretch of the levee was considerably below grade, rendering it necessary for the levee board to expend a large amount of money to keep ahead of the rising water and prevent overtopping.

The same statement will apply to the short line across Leland Neck just below Greenville to a more marked extent, as much greater changes have taken place here. At this locality the blowing up of a considerable portion of the old abandoned levee on the lower side of the neck, which levee acted as a spur to pond the water next to the cross levee and keep the main current away from it, has proven a serious mistake and has turned out to be disastrous in the extreme, as the effect has been to induce a direct flow across the neck contiguous to the main levee, causing deep washouts, endangering the safety of this levee during the high water, and necessitating a large expenditure to save it from destruction.

A crevasse in this levee was only avoided by incessant work day and night, the expenditure of a large quantity of stone and other material by the United States, and of sacks, lumber, and labor by the levee board. This large expenditure would not have been required had the old abandoned levee been raised instead of destroyed.

The conditions across this neck left by the high water are serious and such that a large expenditure both for revetment purposes on the upper side of the neck and also for the construction of a long spur levee reaching, if possible, into the heavy timber will, it is believed, be necessary before the next high water in order to prevent a cut-off taking place in the near future.

A cut-off would be not only detrimental as upsetting the regimen of the river below, but also disastrous to the commercial interests of the city of Greenville, as the town would in the course of a few years be practically on a lake similar to Vicksburg, with no river communication during low water, and therefore without the advantage of river competition, which it now has. To the levee system below Greenville the effect would be equally damaging, on account of the caving of banks and change in channel that would occur on account of upsetting of regimen of the river, rendering necessary the relocation and rebuilding of important levee lines on both sides of the river.

GENERAL REMARKS.

The high water of 1903 reached above the highest flood previously recorded except at the extreme lower end of the district. At the upper end the stage was 1.2 feet above, at Greenville 2.5 feet above, at Lake Providence 2 feet above, and at Vicksburg 0.5 of a foot below the highest water heretofore known.

At several localities as the rise approached its crest it developed that long stretches of levee on both sides of the river were not up to the grade to which they were supposed to have been constructed.

In some instances in large levees this was undoubtedly due to a bodily settlement or subsidence of the levee itself, in other cases to greater shrinkage in the material than was anticipated when the levees were built, and in other cases to the

[illegible]	
[illegible]	1
[illegible]	1
[illegible]	1
[illegible]	1
[illegible]	1
[illegible]	1
Total	6

[illegible] in high-water operations:

	Steamboats.	Quarter boats.	Barges.
[illegible]	1	2	5
[illegible]	1	3	9
[illegible]	2	3	6
[illegible]	1		
Total	5	8	2

All these boats were withdrawn from service and those belonging to third district returned to the fleet at Greenville after the crest of the rise had passed, except one towboat, which resumed the towing of stone, and two quarter boats and a barge, which were retained at the Reid levee at the request of the president of the fifth Louisiana levee board, to be available should the anticipated return flow through the Yazoo River from the Lagrange crevasse develop sufficient height to require work on the levees below Vicksburg.

Below is a statement of charges against high-water operations:

Pay roll	$4,629.3
Subsistence	1,391.2
Coal, oils, etc	2,158.6
Wire strand, etc	1,225.7
Rock	2,355.3
Sacks	6,500.0
Total expended	18,260.4

CREVASSES.

Three breaks, or crevasses, took place during the high water, one on the Albemarle front (508 L.) on March 27; another on the same day on the Lagrange front about 8 miles below Greenville (481¼ L.), and the last on April 3, at Hollybrook plantation (517 R.).

The break at Albemarle was due to the water overtopping the levee. The levees in this, the lower end of the district, had not been brought up to as high a grade as those at the upper end, and as a result of the ground on the land side of the levee being submerged about 4 feet from backwater entering behind the levee system at the lower end, making it almost impracticable to get sufficient material to raise this long section of the levee line in advance of the rising river, the levee was breached by the water flowing over the top. The length of this break is reported as 1,100 feet.

The crevasse on the Lagrange front took place just before the crest of the rise had passed. The ends of the levee on both sides of the crevasse [illegible] rapidly [illegible] wide. The break occurred about 11 a. m., and before night it was over [illegible] and more than one half of Greenville was from 1 to 3 feet under [illegible]

It was the intention of the levee board to at once make an effort [illegible] ends of the levee so as to restrict the flow as much as possible. All [illegible] were made to this end. The necessary quarter boats, barges, et[illegible] [illegible] brought from Huntington [illegible] the city authorities a[illegible] the [illegible] levee in Greenvill[illegible] [illegible] to widen rapidly [illegible] The force of co[illegible] [illegible] current from th[illegible] and no further w[illegible] to render it feas[illegible] [illegible] entire flow. A[illegible] board decided to attempt the work [illegible] anticipated [illegible] [illegible] local changes in the high-water slope. This latter applies more particularly near localities where levees were built across narrow necks and the former levee lines around the points abandoned, and to the levees to some distance both below and above Greenville, where the greatest divergence from former flood heights occurred. That a bodily settlement, where levees are of great height, due to compressibility of the soil, may be expected, especially where built across old lake beds, is well understood.

To show how unstable are the foundations upon which some of the large levees are constructed the result is given of a number of trial borings made under your direction in 1902 along the line of the new Jenkins loop before that levee was constructed. This levee passes across the lower end of Lake Bolivar.

At a boring immediately in rear of where the almost unprecedented settlement of the Stop Landing levee took place in 1898 41 feet of soft mud and slush were penetrated before sand was reached. The other borings range from 5 to 15 feet of clay, then silt, then extremely fine quicksand was reached, which gradually increased in size until coarse sand and fine gravel were encountered. The character of the material found in each boring is given below. For location of borings reference is made to the accompanying sketch.[a]

Table of borings at Choctaw Bend, Miss., May 13 to June 4, 1902, along proposed line of Jenkins Loop, Stations 3100–3234 (434 L.).

Depth (feet).	Kind of material and distance (feet) below surface.						Remarks.
	Buckshot, clay, or loam.	Fine sand.	Blue silt.	Quicksand.	Coarse sand.	Sand and gravel.	
66	0–10	....	10-51	51–60	60–66	....	Very slushy at 25 to 30 feet.
46	0–15	....	....	15–30	30–36	36 40	Considerable quicksand at from 5 to 1 feet.
50	0–10	36–40	....	10–36	40–45	45–50	Sand strictly coarse at 36 to 40 feet highly saturated.
57	0–10	10–20	....	20–50	....	50–57	
63	0–5	5–15 34–45	....	15–35 45–55	55–63	....	Sand at 35 to 45 feet, dry.
54	0–10	34–45	10–20	20–35	....	45–54	Silt, slightly mixed with fine sand.
56	0 5	15 20 40 50	20–40	5–15	....	50–56	Silt same character as in first boring above.
50	0–10	....	....	10–40	40–45	45–50	Very slushy from 10 to 30 feet.

NOTE.—At all borings water was obtained at a depth not exceeding 12 feet.

As many of the large, important levees are built on foundations similar to this, it is not surprising that a gradual settlement should be continually going on from year to year and that after a few years they should be found considerably below the grade to which they were originally constructed.

The material of which the levees in different localities are built is not of the same character, but as a constant allowance for shrinkage is made for all soils in the original construction, and as some soils shrink much more than others, levees, although built with the same shrinkage allowance, will in the course of a few years settle unevenly and will not stand up to the same height, relatively, as when constructed.

This probably accounts for the fact that some of the levees were found to be at a lower grade than anticipated.

The abnormal height above the preceding high waters in the middle portion of the district also accounts for these apparent low grades, as well as the change in slope due to building the short lines below Huntington and across the neck at Leland. With these conditions it required active, continuous, and persistent work over long stretches to keep the levees above the rising water.

The levee-board officials were assisted by the Government engineers, inspectors, and other employees. Towboats, material barges, and material were furnished by the Government for this work, and, with the assistance of the planters, labor from plantations, and convicts, an organized, energetic, and determined effort was made along the entire line to prevent a break in the levees.

It is believed that the two principal crevasses were due to inherent defects in the construction of the original levee itself, as well as to insufficient section.

The break in the levee at Lagrange occurred in the daytime, just before the culmination of the rise, without warning, in an old levee that had been enlarged from time to time. The section of this levee was: Crown, 8 feet; side slopes, 1 on 3; height, 12 to 13 feet, with a small banquette 20 feet wide, the top of which was 9 to 10 feet below the crown of levee.

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[a] Omitted.

The crevasse at Hollybrook was also in an old levee that had been enlarged. Height of levee was 19 feet, with 8-foot crown; slope, 1 on 3; top of banquette 10 feet below crown of levee; width of banquette, 20 feet. This break occurred after the highest water had passed and the river had fallen more than 2 feet. The danger of a break was considered as being over, and the diligence before displayed in watching and guarding the levees had been relaxed. It is believed that this crevasse might have been prevented if the careful inspection of the levees that had prevailed before the rise reached its crest had been continued for a few days longer.

The importance of strengthening weak places and points where trouble has been experienced in former floods in advance of an anticipated high water can not be urged too strongly. At several points it became necessary for the levee boards to expend a large amount of labor and material, when the same results could have been obtained much more economically by a small amount of earthwork done at the proper season.

Work done during high water, as is well known, is extremely expensive, is temporary in its nature, and of no lasting benefit.

The levee system in this district has undoubtedly been fully tested, and under all the conditions it may be considered fortunate that no other breaks took place, as there were many weak places developed that required the utmost care and attention to hold intact.

Crevasses may be expected to occur until all levees are brought up to a sufficient section to withstand the long-continued strain due to the water remaining for weeks near their top.

During the flood of 1891, while the care and protection of the levees in the district was immediately in my charge, my attention was repeatedly called by breaks in the line to insufficiency of the section of a great many of the levees, and also to the evident lack of care under which many of the older levees were constructed, as evidenced by logs and stumps left in the original embankment.

The result of an inspection of the levees on both sides of the river at the time led to the suggestion of modifications as to the general methods of construction, and also an increase in the levee section itself, the recommendation being that the addition be made in the form of a banquette on the land side as being the most economical as well as the most judicious disposition of the material which it was necessary to add in order to make the levees secure. These recommendations and suggestions were embodied in my report of 1891 to Capt. C. McD. Townsend, Corps of Engineers. (See Annual Report Chief of Engineers, 1891, pp. 3648-3650.)

Since then the method of strengthening the levees by adding a banquette on the land side has been extensively adopted for high levees and the size of the muck ditch materially reduced, being now generally restricted to an exploring ditch for the purpose of examining the foundations and the detection of any defects that may exist.

The observations made during the flood of 1897 and the experience gained during the recent high water demonstrate, it is believed, the necessity of a greater section for all levees over 8 feet in height than what is usually called the standard section, viz. 8-foot crown, slopes 1 on 3, with banquette.

The additional section recommended due to raising the banquette is necessary to prevent dangerous sloughing on the bank slope when the levees have become thoroughly saturated by water standing against them for any great length of time. Especially is this the case when the levees are built of light and porous soil so common along the river front.

As, for economical reasons, it is generally impracticable to select the material, the section adopted should be one that would be safe under all conditions and in all soils generally met with.

No breaks or crevasses have ever occurred in levees that have been reenforced with banquettes, where these banquettes were of sufficient height to give additional width to the standard section above a height 8 feet below the top of the levee.

The section I would suggest, which is virtually an increase in height and width of banquette above that now generally used, is a slight modification of that I suggested in 1891. The dimensions are as follows:

Proposed standard section.—Crown, 8 feet; front slope, 1 on 3; back slope, 1 on 3. Banquette to extend within 6 feet of top of levee; width of top of banquette, twice the height of the levee; minimum width of banquette, 20 feet; top slope of banquette, 1 on 10; back slope, 1 on 3.

An examination of figures 1, 2, and 3, submitted herewith (see plate), will indicate the grounds on which this particular section is recommended.

On nearly all levees where the slopes are 1 on 3 or less, after the water has stood against the levee up to or near the crown for any great length of time, a careful examination of the back slope will show that below a plane from 6 to 8 feet vertically below the top of the levee the surface is soft, soggy, and spongy and water soaked, indicating the distance from the top that the saturation due to the water on the front side begins. Above this plane the back slope is generally found to be dry.

Assuming this plane for safety at 6 feet vertically below the top of the levee, and joining this with the point of intersection of the crown and front slope, as shown by the line AB, we have approximately represented the line of saturation in the section. Extending this line downward to the natural ground at the base of the levee, it falls beyond the 1 on 3 slope, indicating that a flatter slope must be used in order to give the necessary security against sloughing. This approximate plane of saturation has a slope of about 1 on 4½. Using a back slope of 1 on 4, shown by the dotted line, it is seen that this section can hardly be considered safe against the danger of sloughing, especially for the higher levees. Besides, it places an excess of material where not needed, as practical experience has demonstrated that the upper part of the section has ample strength.

The width of the banquette, theoretically, should be a function of the height of the levee, and as the outer part of banquette will eventually be used, probably as a roadway, at least during the summer and when there is no water against the levees, it is suggested that the minimum width be at least 20 feet, and for levees 10 feet in height and more that the width of banquette be made twice the height of the levee.

This will give ample security, as the levees in this district, when built to the final grade, will closely approximate an average of 20 feet in height, allowing 3 feet as a margin above the highest water. This will give a width of banquette at all points which will be amply sufficient to allow a good roadway, except during times of high water, along the outer edge without encroaching on or injuring the base of the levee proper.

All travel should, of course, be excluded from the crown of the levee to allow it to be thoroughly covered with sod.

Figures 1, 2, and 3 show sections as proposed for levees 20, 15, and 10 feet in height. Below is given a table showing, for comparision, the amount of yardage in 100-foot lengths of levee with sections as follows: Eight-foot crown, slopes 1 on 3; 8-foot crown, front slope 1 on 3, back slope 1 on 4, and the proposed standard section with banquette. The percentage of increase of the two latter sections over a levee with slopes of 1 on 3 without banquette is also given.

Table of quantities contained in present and proposed levee sections.

[Unit, 100 feet length.]

Height of levee.	8-foot crown, slopes 1 on 3.	Additional yardage to give back slope 1 on 4.	8-foot crown, front slope 1 on 3, back, 1 on 4.	Per cent of increase over section with slopes 1 on 3.	Banquette width twice height of levee.	Proposed standard section with banquette.	Per cent of increase over section with slopes 1 on 3.
Feet.	*Cubic yds.*	*Cubic yds.*	*Cubic yds.*		*Cubic yds.*	*Cubic yds.*	
8	948	118	1,066	12	50	998	5
9	1,167	150	1,317	12	98	1,265	8
10	1,407	185	1,592	13	155	1,562	11
11	1,670	224	1,894	13	222	1,892	13
12	1,950	266	2,222	13	299	2,255	15
13	2,263	312	2,575	13	384	2,647	17
14	2,593	362	2,955	13	479	3,072	19
15	2,944	416	3,360	14	583	3,527	20
16	3,319	474	3,793	14	697	4,016	21
17	3,715	535	4,250	14	820	4,535	22
18	4,133	600	4,733	14	952	5,085	23
19	4,574	668	5,242	14	1,093	5,667	24
20	5,037	740	5,777	14	1,244	6,281	25
22	6,029	896	6,925	14	1,574	7,603	26
24	7,111	1,066	8,177	14	1,941	9,052	27
26	8,231	1,251	9,532	15	2,346	10,627	28
28	9,540	1,541	10,991	15	2,788	12.328	29
30	10,888	1,666	12,554	15	3,267	14,155	30

The foregoing may be summarized as recommending an increase in the present standard section of levees by adding both to the height and width of the banquette on all levees over 8 feet in height. The particular form of section recommended is believed, from observation covering a period of several high waters, to be a rational and judicious distribution of material where needed to give security to the levees after they have had to withstand for a considerable length of time the effect of the water being near their tops.

Respectfully submitted.

ARTHUR HIDER,
United States Assistant Engineer.

Capt. CHAS. L. POTTER,
Corps of Engineers, U. S. Army.

REPORT OF MR. GEORGE C. THOMAS, SUPERINTENDENT.

GREENVILLE, MISS., *May 1, 1903.*

SIR: The following report on revetment work in the Third district during the season of 1902-3 is respectfully submitted:

The annual low-water surveys disclosed the following damage to the different revetments:

Lake Bolivar revetment (417 L.).—Several small sloughs in the upper bank work.

Ashbrook Neck revetment (446 L.).—Extensive scour behind head of work and a small cave in upper slope, destroying paving from ranges 96 to 98.

Greenville Harbor revetment (478 L.).—Complete destruction of upper bank work, ranges 104 to 107, and a considerable inshore extension of the scour behind head of work.

Lake Providence revetment (542 L.)—One small break or slough in upper slope between ranges 96 and 98, and a general lowering of the subaqueous work throughout the reach covered by the big eddy, ranges 96 to 110.

With the exception of a 500-foot upstream extension to the Ashbrook Neck revetment no new work was projected for the season, operations being confined to repairing and strengthening existing works.

GREENVILLE HARBOR.

The force was organized and operations begun at Greenville Harbor September 1, 1902. One small channel mattress, 150 feet width, with necessary shore connections, was constructed and sunk in front of the break between ranges 104 and 107.

A pocket mat of 372 squares, forming a shore connection with repair work of previous seasons, was constructed and sunk between ranges 101 and 103, and the break regraded and repaved from ranges 101 to 107.

This work, with the exception of a small portion of the paving, was completed on September 29 and the force transferred to Ashbrook Neck, the unfinished paving being completed at a more favorable stage of water by a small force organized for the purpose of making repairs at Lake Bolivar front.

ASHBROOK NECK.

The work originally projected for this point comprised the construction of a 500-foot upstream extension of the revetment, the repaving of the break in the upper slope between ranges 96 and 98, and the reenforcing of the subaqueous work with fascine mats 250 feet in width, from range 106 downstream as far as funds would permit.

Operations were begun October 1 and completed November 28 with the exception of 200 squares of paving, which was subsequently completed by a small force organized for that purpose at a more favorable stage of water.

The extension of the work was constructed in the usual manner, with fascine mats 300 feet in width; upper bank slope 1 on 4, the slope being covered with 10-inch stone paving.

To repair the cave in the upper bank, ranges 96 to 98, a pocket mat reaching well out over the original mat was constructed and sunk in front of it and the upper bank resloped and repaved.

The work of reenforcing the subaqueous work from range 106 downstream was interrupted, after the construction and sinking of one mat 940 feet long, by the removal of the outfit to Lake Providence for the purpose of repairing a second break in the revetment at that point.

LAKE PROVIDENCE.

The work at this point comprised the construction of two channel mats 250 feet in width with necessary shore connections, to cover the breaks between ranges 96 and 98 and ranges 104 and 106, and the resloping and paving of the upper bank.

Operations were begun December 1 and completed December 27, and the outfit returned to fleet.

The prosecution of this work was seriously interfered with by a rapid and continuous rise in the river, resulting in the troubles usually attending this class of work under such conditions, such as running drift, shifting of plant, changing of strains, etc., and a reduction in the amount of upper bank paving, the shore edge of mattress reaching up the slope to an elevation of about 20 feet, Lake Providence gauge.

LAKE BOLIVAR FRONT.

The work at this point, which consisted in resloping and repaving a few small sloughs in the upper slope, was done by a small force engaged for the purpose. The work was begun October 15 and completed November 7.

HYDRAULIC GRADING.

With the exception of the work at Lake Bolivar front, the season's grading was done by grader No. 1 with single crew. It was necessary to reduce the water pressure to 60 pounds on account of defective hose.

The average cost of grading for the season was $1.15 per linear foot.

MATERIAL.

Brush and poles were furnished under contract by Messrs. Hunter & Frey, of Memphis, Tenn., being delivered on barges at Gaines Landing, Carters Point, and Leota.

Stone was procured from reserve on bank at Greenville, loaded by Government force, and under contract with Z. S. Claggett & Co. delivered on Government barges at Greenville, Miss.

The complete failure of contractor to furnish stone during the early part of the season necessitated the loading of part of the reserve with wheelbarrows at a very low stage of water. The cost of loading the stone was 64 cents per cubic yard, with an average wheel of 400 feet.

Towing and harbor work was done by the steamer *Arthur Hider* with single crew. The boat was put in commission September 1 and returned to fleet December 30. Average cost per day was $50.

Owing to increase in the cost of labor and materials, the cost of the repairs is slightly in excess of that for similar work of previous seasons.

Sketches of the different works showing the season's repairs and detailed statements giving the cost of the different items of work are submitted herewith.

Very respectfully,

GEO. C. THOMAS, *Superintendent.*

Mr. ARTHUR HIDER,
United States Assistant Engineer.

Cost per unit of different kinds of work done, Lake Bolivar front.

Classification.	Units.	Pay roll.	Subsistence.	Material.	Total.	Cost per unit.
Paving bank .... squares..	464	$427.81	$142.51	$1,621.93	$2,192.25	$4.724
Grading bank .... linear feet..	570	145.00	40.00	....	185.00	.324
Property and sundries	....	....	....	....	199.34	....
Total	....	572.81	182.51	1,621.93	2,576.59	....

Cost per square of completed work, $5.527.

Percentage of cost of the various items, Lake Bolivar front.

Items.	Cost.	Per cent.
Pay roll	$572.81	22.293
Subsistence	182.51	7
Materials	1,621.93	62.987
Property and sundry charges	199.34	7.720
Total	2,576.59	100

Percentage of cost of different kinds of work, Lake Bolivar front.

Items.	Cost.	Per cent.
Paving bank	$2,192.25	85.042
Grading	185.00	7.18
Property and sundry charges	199.34	7.778
Total	2,576.59	100

Stone used per square of paved bank was 1.82 cubic yards.

Cost per unit of different kinds of work, Ashbrook Neck.

Classification.	Units.	Pay roll.	Subsistence.	Material.	Total.	Cost per unit.
Mat built .... squares..	5,105	$7,018.74	$2,574.81	$22,826.18	$32,419.73	$6.351
Paving bank .... do....	767	522.82	185.80	4,947.16	5,655.78	7.37
Grading bank .... linear feet..	950	648.75	147.55	285.98	1,082.28	1.139
Dressing grade .... do....	950	737.09	270.40	....	1,007.49	1.06
Towing .... days..	61	1,411.00	417.40	1,242.43	3,071.66	50.35
Clearing bank	....	65.84	24.15	....	89.99	....
Repairs to old work	....	385.82	141.54	....	527.36	....
Supervision	....	700.00	73.38	....	773.38	....
Outfitting, etc	....	....	....	433.61	433.61	....
Property	....	....	....	2,620.22	2,620.22	....
Memphis office	....	....	....	167.38	167.38	....
Total	....	11,490.89	3,835.03	32,522.96	47,848.88	....

Material expended per square of pocket and channel mat, Ashbrook Neck.

[5,105 squares.]

Material.		Quantity.	Per square.
Brush	cords	7,476.16	1.464
Poles	do	291	.05
Stone	cubic yards	4,395.52	.861
Wire, strand:			
¼-inch	pounds	32,865	6.43
$\frac{5}{16}$-inch	do	6,954	1.36
⅜-inch	do	19,326	3.78
½-inch	do	4,900	.96
Galvanized wire, No. 12	do	9,820	1.8
Silicon bronze wire	do	3,450	.67
Clips, assorted	number	2,100	.41
Staples	pounds	525	.10
Spikes	do	190	.03

Percentage of cost of different kinds of work, Ashbrook Neck.

Kinds.	Cost.	Per cent
Mat building	$32,419.73	67.7
Paving bank	5,655.78	11.8
Clearing bank	89.99	.1
Hydraulic grading	1,082.28	2.2
Dressing grade	1,007.49	2.1
Minor repairs to old work	527.38	1.1
Towing	3,071.66	6.4
Miscellaneous and outfitting	433.61	.9
Property purchased	2,620.22	5.4
Memphis office	167.38	.3
Supervision	773.38	1.6
Total	47,848.88	100

Percentage of cost of different items of work, Ashbrook Neck.

Items.	Cost.	Per cent.
Pay roll	$11,490.89	24.0
Subsistence	3,835.08	8.0
Material	29,419.18	61.4
Property	2,620.22	5.4
Miscellaneous, etc	316.18	.6
Memphis office	167,38	.3
Total	47,848.88	100

The amount of stone expended on bank paving in this work was 2,485.7 cubic yards for 767 squares, or 3.24 cubic yards per square.

Cost per unit of different kinds of work, Greenville Harbor.

Classification.		Units.	Pay roll.	Subsistence.	Material.	Total.	Cost per unit.
Mat built	squares	1,015	$2,063.80	$665.70	$4,182.41	$6,931.91	$6.8
Paving bank	do	655	868.98	277.61	3,886.38	5,032.97	7.6
Grading bank	linear feet	600	492.94	106.26	172.14	771.34	1.2
Dressing grade	do	600	217.02	69.33		286.35	.47
Towing	days	29	739.26	211.17	418.15	1,368.58	47.2
Minor repairs			143.20	45.74		188.94	
Superintendence			350.00	29.87		379.87	
Outfitting, etc			148.33	51.87	140.06	340.26	
Memphis office					209.38	209.38	
Total			5,043.53	1,457.55	9,008.52	15,509.60	

Material expended per square of channel and pocket mat, Greenville Harbor.

[1,015 squares.]

Material.		Quantity.	Per square.
Brush	cords	1,632.6	1.608
Poles	do	46.92	.046
Stone	cubic yards	543.34	.535
Wire strand:			
¼-inch	pounds	5,925	5.837
3/16-inch	do	3,450	3.399
⅛-inch	do	700	.689
Silicon bronze wire	do	600	.591
Galvanized wire, No. 12	do	2,830	2.788
Magnolia clips	number	300	.295
Staples	pounds	175	.172

Percentage of cost of different kinds of work, Greenville Harbor.

Kinds of work.	Cost.	Per cent.
Mat building	$6,931.91	44.694
Paving bank	5,032.97	32.46
Hydraulic grading	771.34	4.968
Dressing grade	286.35	1.847
Towing	1,368.58	8.825
Minor repairs	188.94	1.213
Outfitting and miscellaneous	340.26	2.195
Superintendence	379.87	2.449
Memphis office	209.38	1.349
Total	15,509.60	100

The amount of stone expended on bank paving in this work was 1,725.039 cubic yards for 655 squares, or 2.633 cubic yards per square.

Percentage of cost of the various items of work, Greenville Harbor.

Items.	Cost.	Per cent.
Pay roll	$5,043.53	32.53
Subsistence	1,457.55	9.39
Materials	8,668.72	55.89
Property and miscellaneous	339.80	2.19
Total	15,509.60	100

Cost per unit of the different kinds of work, Lake Providence.

Classification.		Units.	Pay roll.	Subsistence.	Material.	Total.	Cost per unit.
Mat built	squares	2,088	$3,192.98	$1,308.26	$9,768.31	$14,269.55	$6.834
Paving bank	do	75	70.46	28.88	432.00	531.34	7.084
Grading bank	linear feet	460	326.74	91.71	31.77	450.22	.978
Towing	days	31	729.50	203.14	673.90	1,606.54	51.82
Repairs to old work			70.46	28.88		99.34	
Supervision			600.00	54.93		654.93	
Outfitting, etc					231.48	231.48	
Total			4,990.14	1,715.80	11,137.46	17,848.40	

Material expended per square pocket and channel mat, Lake Providence.

[2,088 squares.]

Material.	Quantity.	Per square.
Brush ....cords..	2,999.65	1.4
Poles ....do....	151.30	.0
Stone ....cubic yards..	2,238.44	1.0
Wire strand:		
½-inch ....pounds..	14,156	6.7
5/16-inch ....do....	8,745	4.1
¼-inch ....do....	4,000	1.9
Galvanized wire, No. 12 ....do....	4,455	2.1
Silicon bronze wire ....do....	978	.4
Magnolia clips ....number..	100	.0
Staples ....pounds..	200	.0
Spikes ....do....	100	.0

The amount of stone expended on bank paving in this work was 225 cubic yards for 75 squares, or 3 cubic yards per square.

Percentage of cost of different kinds of work, Lake Providence.

Kinds of work.	Cost.	Per cent.
Mat building	$14,269.55	79.9
Paving bank	531.34	2.9
Minor repairs to old work	99.34	.5
Hydraulic grading	450.22	2.5
Towing	1,606.54	9.0
Supervision	654.93	3.6
Outfitting, etc	231.48	1.3
Total	17,843.40	100

Percentage of cost of the various items of work, Lake Providence.

Items.	Cost.	Per cent.
Pay roll	$4,990.14	27.96
Subsistence	1,715.80	9.6
Material	10,980.74	61.5
Outfitting, etc	156.72	.8
Total	17,843.40	100

APPENDIX 3 B.

REPORT OF MR. A. MILLER TODD, SUPERINTENDENT.

GREENVILLE, MISS., *May 9, 1903.*

CAPTAIN: I have the honor to submit the following report of operations in the Lower Yazoo levee district for the year ending May 1, 1903.

Extent of district and yardage.—The line of levee extends from the Coahoma-Bolivar County line (367 L.) to a point in Warren County on Eagle Lake, about 7 miles back of Brunswick Landing (580 L.), all in the State of Mississippi. The line has been lengthened 158 feet by a new loop at Duvall (567 L.). The total length of the levee line is now 188.34 miles. The contents of the levees as estimated May 1, 1902, were 32,150,229 cubic yards. There have been added during the year by the United States 1,004,258 cubic yards, and by the levee board 482,391 cubic yards; total added, 1,486,649 cubic yards. Deduct for levees thrown out by new loops and lost by crevasses 373,187 cubic yards, gives net amount added to levee line, 1,113,462 cubic yards. The levee line at the present time contains 33,263,691 cubic yards.

The following table shows amount of yardage deducted for new loops and crevasses:

Locality.	Stations.	Miles below Cairo.	Length.	Cubic yards.
			Feet.	
Lagrange crevasse	153+75 to 192+50	480 L.	3,875	102,339
Duvall loop	4669+88 to 4780+48	567 L.	11,060	247,000
Albemarle crevasse	4857 to 4868	569 L.	1,100	23,848
Total				373,187

CONSTRUCTION.

During July the following project for levee work was adopted, and proposals invited covering same, to be opened August 20.

Stations.	Miles below Cairo.	Kind of work.	Net grade proposed.	Estimated yardage.
3100-3125	434 L.	New levee	3 feet above 1897 high water[a]	143,000
3125-3156	434 L.	do	do.[a]	145,000
3156-3189	434 L.	do	do.[a]	145,000
3189-3229	434 L.	do	do.[a]	145,000
3229-3245+42a	434 L.	do	do.[a]	147,000
2572-2880	531 L.	Banquette	5 feet below 1897 high water[a]	60,000
3800-3942	552 L.	Enlargement	4 feet above 1897 high water	105,000
4670-4725	567 L.	New levee	3 feet above 1897 high water	137,500
4725-4780	568 L.	do	do	137,500
4780-4924a	568 L.	Enlargement	4 feet above 1897 high water	120,000
4887-5230	569 L.	do	do	161,000

[a] Grade of banquette was raised from 5 feet below 1897 high water as adopted to 2 feet below 1897 high water, the levee board paying for the increase in yardage.

The total contents amounted to 1,446,000 cubic yards, estimated to cost $246,000 an average of 17 cents per cubic yard. When the bids were opened it was found that the lowest bids would make the work cost $282,000, which was $22,000 more than was available for earthwork. Bids on the following sections were rejected: Stations 3800-3942 (552 L.), 4780-4924a (568 L.), and 4887-5230 (569 L.), the lowest prices bid being considered too high. The grade on two of these sections was changed from 4 feet above the 1897 high water to 3 feet above, reducing the yardage about 71,000 cubic yards, and all three readvertised and bids opened October 2. The cost, according to prices received under the new letting, was found to come just within the amount available for the work. The amended project amounted to 1,375,000 cubic yards; cost at the prices let, $259,578.50, an average of 18.9 cents per cubic yard.

Contractors were all slow starting to work. Only four contracts were started in September, and only seven of the twelve contracts were in progress by the latter part of October. Two contracts, viz, stations 4780-4890 (569 L.) and 5000-5170 (570 L.), have not had any work done on them to date. During September, October, and November the weather conditions were excellent; from January to March very little progress was made on account of the excessive and frequent rains. Only one contract, stations 3156-3189 (434 L.), was completed on contract time (February 1, 1903). The river reached a flood stage during March, stopping work on all the contracts, and to date none of the other contracts have been completed. The two contracts, stations 4670-4725 (567 L.) and 4725-4780 (568 L.), I. R. Bobbitt, contractor, constituting the Duvall loop, being built to cover levee threatened by caving bank, were not prosecuted with sufficient diligence by the contractor.

On account of the rapid caving of the river bank threatening the old levee a force of 50 teams, in addition to the contractor's force, was put on the upper contract in December and continued until February 1, leaving the contractor only about 35,000 cubic yards to complete with over a hundred teams on the ground. The rains were so excessive during the month and until March 15 that the contractor was not able to entirely complete the work. It was left in such shape, however, that had the front levee caved off the flood would have been restrained by the new loop.

On November 20 a project was submitted to cover amount to be expended in this district, available during the fiscal year ending June 30, 1904, with a view to letting at once so as to allow the contractors a year in which to complete. The following table shows project as adopted:

Stations.	Miles below Cairo.	Kind of work.	Net grade proposed.	Estimated yardage.
1038-1080	380 L.	New levee	3 feet above 1897 high water[a]	160,00
1080-1116	380 L.	do	do	175,00
1116-1150	380 L.	do	do	145,0
1150-1183	380 L.	do	do	160,0
1183-1226	380 L.	do	do	160,0
1840-2070	402 L.	Enlargement	4 feet above 1897 high water	160,0
2130-2230	403 L.	do	do	65,0
100- 200	480 L.	do	do	60,0
600- 790	496 L.	do	do	100,0
1346-1730	500 L.	Banquette	5 feet below 1897 high water[b]	100,0
1730-2108	505 L.	do	4 feet below 1897 high water[b]	85,0

[a] Grade of banquette was raised from 5 feet below 1897 high water, as adopted, to 2 feet below 1897 high water, the levee board paying for the increase in yardage.

[b] Grade of banquette will be built to 2 feet below 1897 high water, the levee board paying for the increase in yardage.

A total estimate of 1,370,000 cubic yards to cost about $244,000. Proposals were received at the Memphis office and opened February 12, 1903. The cost of the work as awarded to the lowest bidders is $201,638, an average of 14.7 cents per cubic yard.

A total of 2,745,000 cubic yards was let during the year at an average cost of 16.8 cents.

A small amount of work was done on three of the contracts let February 12. Work was suspended on account of high water March 15.

A statement is submitted showing names of contractors, prices, and all construction details, etc.

Levee board construction.—A statement accompanies this report, showing the work done by the Mississippi levee board during the year. They received proposals on August 25, covering 950,000 cubic yards of earthwork. All the work was let to one firm for 22 cents per cubic yard, their bid being considered the best and the lowest. The levee board have also obligated themselves to pay for 344,000 cubic yards, to be included with Government contracts, as mentioned in tables showing the adopted Government projects.

Total work let during the year.—The total amount of work put under contract by both the United States and the levee board is 4,039,000 cubic yards, of which only 1,486,649 cubic yards have been placed, leaving 2,551,351 cubic yards still to be done.

REPAIRS AND MAINTENANCE.

Sodding.—The entire line was found to have a fairly uniform mat of sod, and no repairs of this nature were necessary.

Weed cutting.—Proposals for cutting weeds along the entire line of levee were received July 10, and let to M. J. Pilcher at 33 cents per station. Work was commenced July 21 and completed October 15, 9,754 stations cut, at 33 cents per station, costing $3,218.82.

HIGH-WATER MAINTENANCE.

Early in March it became evident that the river would reach the flood stage throughout the district and an organization for the maintenance of the line would have to be effected. In compliance with instructions from your office, I turned over to the levee board all the inspectors employed in the field but two, to assist with the operations of high-water protection.

The levee board proceeded to effect a thorough organization from the Coahoma-Bolivar county line to the lower end of the district at once. By March 10 the organization was complete. It was soon evident that the previous highest waters would be exceeded along the entire line. The condition of the levees was just about the same as reported in the last annual report. (See Annual Report of the Chief of Engineers, Supplement, p. 123.) On account of the excessive rains during the latter part of February and the first fifteen days in March, causing several successive rises in the Arkansas and White rivers, the ultimate height the water would finally reach along the district was uncertain.

It was realized when the water came to the bottom of the local gauges along the line, that the present flood was departing from a parallel with the 1897 high water at many points.

This was the first flood of any importance to come against the Huntington Short Line, stations 3331–3562 (436 L.), and although the grade line had been raised considerably at the lower end, the water impounded so much and the plane changed so decidedly (due to the shorter route of a large volume of water) that much work had to be done to keep the water from overtopping the levee. It is a noteworthy fact that the 1903 high-water line more nearly paralleled that of 1898 than the 1897 high-water line. A comparative profile is submitted herewith, showing the heights of the 1897, 1898, and 1903 high waters.

The following table gives the height of the 1903 high water above those of 1897 and 1898 at prominent points along the district.

Stations.	Miles below Cairo.	Locality.	Above 1897 high-water.	Above 1898 high-water.	Remarks.
			Feet.	*Feet.*	
240	370 L.	Australia	1.2	2.2	
860	378 L.	Gunnison	1.5	2.5	
1500	398 L.	Rosedale	1.5	2.7	
1810	402 L.	Beulah	1.2	2.5	
2600	417 L.	Bolivar	.7	2.4	
3030	433 L.	Eutaw Landing	.1	1.8	
3400	439 L.	Arkansas City gauge	1.2	1.9	Opposite station 3400.
3600	457 L.	Bolivar-Washington county line.	3.1	4.1	Just below end of Huntington Short Line.
3675	458 L.	Mound Bayou	1.4	2.4	
3882	461 L.	Carters Neck	1.1	2.2	
4270	478 L.	Greenville gauge	2.4	3	
1500	502 L.	Longwood	2.3	2.6	
2000	513 L.	Leota	2.3	2.3	
2900	538 L.	Mayersville	2.5	2.7	
3400	542 L.	Lake Providence gauge	2	2.2	Opposite station 3400.
4000	555 L.	Fitlers	2.6	2.4	
4800	568 L.	Duvall	2.6	2.8	
5200	573 L.	Brunswick	3	3	

I am of the opinion that the Huntington Short Line had the effect of lowering the plane at Bolivar and Arkansas City, and raising the plane at the Bolivar-Washington county line.

In many other places along the district the flood plane showed very erratic tendencies, due to unforeseen and local conditions. Nearly all around Lake Lee, stations 800–1200 (495 L.), the 1903 water was uniformly 2.8 feet above the 1897 high water. From Shipland to Fitlers, stations 3500–4000 (550 L.), the water came from 3.5 feet to 2.6 feet above the 1897 high-water line. The Hays Loop, stations 4076–4243 (554 L.), had been constructed to a grade line based on the 1897 high water, which along this reach was about five-tenths of a foot under the 1898 high water, and this year's water went 3 to 3.8 feet above the 1897 high water.

A statement is submitted herewith showing work done and materials used along the entire line.

Cost of high-water protection of levees.

Amount expended by the Mississippi levee board to May 1	$105,331.95
Amount expended by the United States for steamboats and preparation of plant, etc	4,039.12
Total	109,371.07

If the levee board and Government contracts had been completed within contract time (February 1, 1903) the cost of the high-water operations would have been in the neighborhood of $50,000 less than the above amount.

Crevasses.—Two crevasses occurred in the district, both on the 27th of March, as follows:

Station breached.	Miles below Cairo.	Day and hour.	Width attained.		Remarks.
			Stations.	Distance.	
				Feet.	
180	480 L	Mar. 27, 11 a. m	153+75 to 192+50	3,875	Failure of levee section almost without warning.
4862	569 L	Mar. 27, 11.30 a. m.	4857 to 4868	1,100	Water over 2 feet above top of levee; topping very weak account 4-foot crown and 2 to 1 slope to start on

Neither crevasse could be charged to neglect, as at both localities forces were at work day and night to maintain the line intact.

Overflow limits.—A map is submitted showing the overflow limits. It also shows the limits of the 1897 overflow and the extent of backwater in 1898, with no levee breaks. The total area flooded is estimated at about 1,460 square miles. There were covered by backwater around the end of the system in 1898 (the gauge at Vicksburg reading 49.4) approximately 600 square miles. It was evidently considerably more than the above amount with a gauge height of 51.8 at Vicksburg, so 860 square miles is a liberal estimate of the area overflowed from the crevasses. Practically this entire amount was overflowed from the upper crevasse at Lagrange. As far as can be ascertained, there were no lives lost, owing to the effectual closure of the crevasse below Greenville (Lagrange) on April 30, shutting out a volume of water of some 20,000 cubic feet per second. The entire area overflowed will be freed from water in time to be planted for this year's crop. Hence the losses will be confined to live stock, fences, and buildings.

GENERAL REMARKS ON THE HIGH WATER OF 1903.

This flood, paralleling so nearly the high water of 1898, instead of that of 1897, demonstrates that a grade of a fixed height above the 1897 high water will be out of proportion along over half of the district. I would recommend that for all work in the future a provisional grade of 2.5 feet above the 1903 water be adopted and that the entire line be enlarged or topped up to that grade, as near as possible, by the approach of the next high-water season. Elsewhere in this report is given an approximate estimate to put the levees up as above recommended.

I desire to note that the levels run over the top of the levee immediately after the water had begun to recede showed that all the loops against which the water had stood for the first time had shrunk to below net grade. This is very noticeable along buckshot reaches, and especially on the Hays loop, stations 4078–4243 (553 L.). In many places this work went down more than 2 feet below net grade.

I desire to call attention to my remarks on the subject of sinkage and shrinkage in the last annual report (Annual Report Chief of Engineers, 1902, Sup., p. 124), and would respectfully urge that the subject be taken up and considered with a view to modifying the present specifications so as to increase the percentage allowed for shrinkage, or the adoption of a general rule for an increase in grade height where heavy buckshot is encountered.

The difference in cost of maintenance in favor of the banquettes that have been built to the ultimate Commission grade over those that are 8 feet below the provisional grade of 3 feet above the 1897 water demonstrates that it is wise to build the banquettes up to the final grade. It will be remembered that the standard section of levee as adopted in this district provides that the grade of the banquette is to be only 5 feet below the ultimate high water. Along the reaches where the banquette is standing 8 feet below the top of the levee, and the flood approaches the top, the flood level will be 8 feet above the top of the banquette. It was demonstrated that wherever the above conditions existed the section was palpably deficient.

The greater part of the trouble experienced at the base of the levee was along reaches where very old levees have been adopted and enlarged up to the present section; where sloughs or slashes crossed the levee or came in close proximity to them; or in sandy formations where the land-side borrow pits had been excavated nearer than 100 feet to the slope of the levee. Therefore I think it would be conducive to economy along all reaches founded on very old levees, if not over 12 feet high, to move back a safe distance and build an entire new levee; if over 12 feet high, to excavate a ditch down to and below the natural surface of the ground so located as to cut through the defective section and fill with good, clean material. Where sloughs and swales cross the line of levee, and where old borrow pits on the land side provide less than a 100-foot berm, they should be filled with good material so as to form a uniform berm along the land-side base of the levee 100 feet wide. All travel of any nature whatsoever should be removed beyond the 100-foot berm.

SURVEYS, MAPPING, ETC.

Shore line and location surveys have been made for new loops at Jenkins (434 L.), Duvall (567 L.), and at Waxhaw (380 L.). Maps, profiles, and blue prints of these surveys were made up and forwarded to your office.

A party took borings along the proposed Jenkins loop with a view of ascertaining whether the proposed levee location would be feasible. The work was done under the direction of Mr. Arthur Hider, United States assistant engineer in charge of channel work. For report of borings, etc., see his report.

HIGH-WATER SURVEYS.

Spikes were set marking the 1903 flood line on all local gauge trees set in 1901 and on a considerable number of new trees. Spikes were also set on trees at intervals from one-half to three-fourths of a mile, from the end of the levee down to Kleinston. After the water had receded so that the men could be released from high-water maintenance seven level parties were placed in the field, and accurate levels were run, connecting and checking the elevations of the spikes and ascertaining height of top of levee. A profile is submitted herewith showing the results of these observations; also showing the high waters of 1897 and 1898 for comparison. Two parties obtained the limits of the overflow and backwater, and a map is submitted showing the result of their observations.

CHANGES IN BANK LINE.

On account of the water being over the bank none of the usual spring shore line surveys have been made. As far as known, caving continues along all the reaches mentioned in the last annual report. The existing levees became so threatened that new loops have been provided for at the following localities: Waxhaw Front (392–394 L.), Eutaw to Stop Crevasse Loop (430–435 L.), and at Duvall to Chotard (568–570 L.). At Shiloh, station 4200 (555 L.), measurements have been made along the old spur levee which indicate that the caving opposite station 4243a has been especially active, and at the present rate of caving the existing line will not last much over a year. This is now the most seriously threatened point in the district that is not covered by proposed new loops under contract.

ESTIMATE FOR CONTINUED CONSTRUCTION.

Practically all the work necessary to place the line to a uniform grade of 3 feet above the 1897 high water has been provided for and is now under contract. The grade of the enlargement below Greenville (4 feet above the 1897 high water) will run only from 0.5 to 1.5 feet above the 1903 water. If possible, it would be well to modify these contracts so as to place them 2.5 feet above the 1903 high water.

Below is given an estimate for placing the entire line to a uniform grade 2.5 feet above the 1903 high water. This estimate is approximate, as sufficient time could not be had to accurately calculate the contents of the proposed work.

Stations.	Miles below Cairo.	Nature of work.	Estimated yardage.	Estimated cost.
260- 861	370-378 L.	Topping	75,000	$18,750
1550-1840	398-403 L.	do	45,000	11,250
2070-2130	403-404 L.	do	10,000	2,500
2230-3410	408-441 L.	do	60,000	15,000
3600-3680	445-446 L.	Enlargement	100,000	20,000
3680-3850	446-460 L.	Topping	20,000	5,000
4150-4200	477-478 L.	do	10,000	2,500
32- 150	479-481 L.	Enlargement in addition to present contract	60,000	9,600
150- 200	481-482 L.	New loop (crevasses)	250,000	40,000
200- 600	482-491 L.	Topping	60,000	15,000
600- 790	491-493 L.	Enlargement in addition to present contract	75,000	12,000
940-1500	494-502 L.	Enlargement	750,000	150,000
1500-2600	502-529 L.	Topping	150,000	37,500
2600-3200	529-537 L.	do	100,000	25,000
3200-3800	537-552 L.	do	100,000	25,000
3800-3942	552-553 L.	Enlargement in addition to present contract	100,000	20,000
3942-4400	553-560 L.	Enlargement	350,000	70,000
4400-4670	560-568 L.	Topping	35,000	7,000
4670-4850	568-569 L.	do	27,000	5,400
4850-4870	569	New loop (crevasse)	100,000	16,000
4870-5170	569-572 L.	Topping	45,000	9,000
5170-5587	572-585 L.	do	75,000	15,000
		Total	2,597,000	531,500

Note.—The enlargement is estimated for standard section; the topping for the following section: Crown 4 feet, back slope 3 to 1, front slope 2 to 1.

The following work will be absolutely necessary during the coming season:

Stations.	Miles below Cairo.	Kind of work.	Yardage.	Cost.
150-200	481 L.	New (crevasse loop)	250,000	$40,000
4850-4870	569 L.	do	100,000	16,000
			350,000	56,000
Repairs of wave wash and restoring section of levee otherwise damaged by the high water			60,000	15,000
Other repairs				10,000
Weed cutting, etc				5,000
Engineering, surveys, etc				14,000
Total			410,000	100,000

The chief engineer of the Mississippi levee board states that the board was forced to borrow $150,000 in order to defray all high-water expenses, and retain enough on hand to pay for outstanding contracts. The above amount is all the board is authorized by law to borrow, and there will be little, if any, available funds for construction during the present year.

Below is a revised estimate of yardage required to construct the levee to a grade 6 feet above the high water of 1897 (Commission grade) with standard section, deducting for all work under contract.

	Cubic yards.	
ENLARGEMENT.		
Embankment	9,794,028	
Stumps, spurs, road crossings, etc	557,085	
Increase for sinking	1,845,700	
		12,196,813
BANQUETTE.		
Embankment	715,760	
Stumps, etc	72,835	
		788,595
Total enlargement and banquette		12,985,408
Add for new loops		1,500,000
Grand total		14,485,408

The expenditure of Government funds in this district is given in a separate statement, the aggregate amounts being as follows:

Designation.	Expenditures.	Per cent.
Construction	$149,367.57	89
Repairs and maintenance, including high-water expenditures	9,325.74	6
Engineering, surveys, etc	9,157.11	5
Total	167,850.42	100
Pro rata charges from Memphis office	4,555.14	
Total expended in Lower Yazoo district	172,405.56	

The following blueprints and statements accompany this report:
Statement of expenditures.
Statement of levee construction by the United States.
Statement of construction by the Mississippi levee board.
Statement of rainfall at Greenville, Miss., during the year.
Statement of operations in high-water protection, Lower Yazoo district.
Blueprint showing overflow area in the Lower Yazoo district.
Blueprint showing high-water slopes, 1897, 1898, and 1903.

Respectfully submitted.

A. MILLER TODD, *Superintendent.*

Capt. CHAS. L. POTTER,
Corps of Engineers, U. S. Army.

Operations for high-water protection in the Lower Yazoo levee district.

Stations.	Miles below Cairo, left bank.	Number sacks used.	Lumber used. *Ft. B. M.*	Remarks.
0-275	366			Small slough at station 150 revetted with brush and sacks.
275-300	370			Numerous bad sand boils at base of levee and in land side borrow pits hooped with sacks.
300-580	370			Sack revetment to check wave wash.
580-594	376			Sand boils hooped and slope of banquette revetted with sacks and brush.
594-850	376			Very little work necessary.
850-920	378			Several sloughs in banquette revetted with brush and sacks.
920-1066	379			Very little work necessary.
0-1066	366-380	48,000	1,600	Total material expended in subdistrict.
1066-1110	380			No work necessary.
1110-1270	380			Sack revetment to check wave wash.
1252	394			Spur topped with teams and sacks; end revetted with brush and sacks.
1270-1290	394			Low levee topped with sacks.
1290-1300	395			No banquette; slope of levee revetted with brush and sacks.
1300-1335	395			No work necessary.
1335-1340	395			Topped with teams.
1340-1394	396			Very little work necessary.
1394-1395	396			Banquette revetted with brush and sacks.
1395-1504	396			No work necessary.
1504-1516	398			Topped with teams.
1516-1595	398			No work necessary.
1595-1600	399			Two bad sand boils hooped with sacks.
1600-1615	399			No work necessary.
1615-1650	399			Topped with sacks and revetted with sacks to check wave wash.
1650	400			Spur topped with sacks.
1650-1690	400			Very little work necessary.
1690-1760	400			Much work was done all along base of levee; numerous bad sand boils were hooped with sacks; levee came near breaking at station 1698+75. Sublevee built around bad place about 600 feet long with wheelbarrows and teams. About 2,000 feet of small sublevee constructed to impound water along other bad places.
1760-1840	402			Several soft places at base of banquette revetted with brush and sacks.
1870-2100	403			No work except revetment in places to check wave wash.
1066-2100	380-403	115,000	10,000	Total material expended in subdivision.
2100-2130	403			End of dike at station 2130 revetted with brush and sacks.
2130-2450	405			No work necessary.
2450-2550	415			Considerable number of sand boils hooped with sacks.
2550-2590	416			No work necessary.
2590-2645	417			Four bad sand boils hooped and slough crossing revetted with brush and sacks.
2645-2660	418			Very little work necessary.
2660-2680	418			Sack and lumber revetment to check wave wash.
2680-2912	418			No work necessary.
2100-2912	403-421	27,000	10,000	Total material expended in subdivision.
2912-2976	421			No work necessary.
2976	425			End of spur revetted with brush and sacks.
2976-3330	425			Very little work necessary.
2912-3330	432-435	20,000		Total material expended in subdivision.
3330-3410	435			No work necessary except sack revetment to check wave wash in places.
3410-3424	437			Topped with sacks.
3424-3436	440			No work necessary.
3436-3510	442			Very low, topped with teams, wheelbarrows, and sacks, mainly with sacks.
3510-3518	443			Enlargement up; no work necessary.
3518-3535	443			Topped almost entirely with sacks; very low.
3535-3562	443			Enlargement up; no work necessary.
3562	443			Spur topped with lumber and sacks; end revetted with brush and sacks.
3562-3570	443			Very low levee, topped with wheelbarrows and lumber.
3570-3576	443			Enlargement up; no work necessary.
3576-3615	443			Topped with teams.
3615-3916	445-460			No work necessary.
3330-3916	435-460	114,000	55,000	Total material expended in subdivision.
3916-4047	460			No work necessary.
4047-4100	475			Topped with sacks and boil hooped at station 4090.
4100-4170	476			No work necessary.
4170-4189	477			Topped with sacks in a few places.
0-32	477			No work necessary.

Operations for high-water protection in the Lower Yazoo levee district—Cont'd.

Stations.	Miles below Cairo, left bank.	Number sacks used.	Lumber used.	Remarks.
			Ft. B. M.	
32-100	480			Base of levee and banquette developed many weak spots; numerous sand boils hooped, and sloughs revetted with brush and sacks.
100-150	481			Generally low, topped with lumber and sacks.
150-300	482			Base of levee and banquette weak and sloughy throughout; many sand boils hooped with sacks, and banquette and slope of levee revetted with brush and sacks. Low levee topped with sacks. Crevasse occurred at station 180 Mar. 27; attained width of 3,875 feet; upper end protected from further widening by a dike of timber, brush, and sacks.
3916-300	460-482	40,000	18,000	Total material expended in subdivision.
141-204	481	110,000	127,500	Protection work built to stop water from running through crevasse; 3,900 feet of protection levee, and 3,000 feet of timber cribbing, faced with sacks. Shut out all inflow at 39.75 on the Greenville gauge. Inflow would have stopped entirely at about 36 feet on the gauge.
300-350	482			Soft places where stock had trampled down the sod revetted with brush and sacks.
350-400	485			Rain and wave wash sacked; some soft places at base revetted with brush and sacks.
400-540	485			Very little work necessary; water very near top, however.
540-890	490			Entire reach from 0.1 to 1.5 feet low; topped with lumber, wheelborrows, and sacks.
890-970	495			Enlargement up; not much work necessary.
970-1112	496			Entire reach overtopped; slightly topped with earth, sacks, and lumber; revetted with sacks to check wave wash.
1112-1400	500			Generally low; topped in many places with lumber, earth, and sacks.
300-1400	483-500	52,000	72,000	Total material expended in subdivision.
1400-1608	500			Levee generally low; topped with lumber, earth, and sacks.
1608-1609	502			Very bad sand boil and sinking levee; revetted and braced with brush and sacks.
1609-1970	502			Very little work necessary.
1970-2097	512			Low in some places; topped with sacks.
2097-2100	514			No work necessary.
2100-2101	515			Crossing of bayou gave much trouble; sublevee built with teams; levee braced with brush and sacks.
2101-2300	515			No work necessary.
1400-2300	500-515	40,000	20,000	Total material expended in subdivision.
2300-2920	516			Very little work necessary.
2920-3085	533			Low places topped with sacks.
3085-3120	535			Revetted with sacks to check wave wash.
3120-3150	535			Low levee; topped with sacks; revetted with sacks to check wave wash.
3150-3200	536			Top of levee about even with high water; no work done.
3200-3250	537			Revetted with sacks to check wave wash.
3250-3295	538			No work necessary.
3295-3897	552			Very low and weak section; topped with sacks and lumber 0.1 to 2.5 feet.
3897-3921	553			New enlargement up; water came within 0.7 foot of top; no work.
3921-3945	553			Levee low; topped with sacks.
3945-4020	553			Water even with top; topped and revetted with sacks to check wave wash.
4020-4080	554			Very low; topped with sacks.
4080-4140	555			Very low; topped with earth and lumber.
4140-4205	555			From 0.5 to 2 feet low; topped with sacks and lumber.
4205-4250	555			Topped with earth and sacks; base soft in spots; revetted with brush and sacks.
4250-4410	556			A little low in places; sack topping used.
4410-4750	560			No work necessary.
4750-4950	563			Very low levee; 4-foot crown, 2 to 1 front slope; topped from 1 to 2.5 feet with lumber and earth taken from land side slope. Back water about 5 feet high on land side of levee. Crevasse occurred at station 4862 Mar. 27; widened out to 1,100 feet; nothing done to stop caving or check water running through.
4950-5000	568			Considerable enlargement up to grade; water within about 0.5 foot of grade of enlargement.
5000-5170	570			Generally about 1 foot low; topped with earth and lumber.
5170-5230	572			Revetted with sacks to check wave wash, and several soft places at base of levee revetted with brush and sacks.

Operations for high-water protection in the Lower Yazoo levee district—Cont'd.

Stations.	Miles below Cairo, left bank.	Number sacks used.	Lumber used.	Remarks.
			Ft. B. M.	
5230-5587	573			Water generally level with top of levee; some low places topped with sacks.
2300-5587	516-573	120,000	70,000	Total material expended in subdivision.
Total.		686,000	384,100	

Levee work in Lower Yazoo levee district above Greenville, May 1, 1902, to May 1, 1903.

Stations.	Miles below Cairo.	Contractor.	Cubic yards in contract, United States.	Cubic yards added by levee board.	Cubic yards placed during year.	Total laborers.	Total teams.
1038-1080	380 L.	M. J. Roach & Co	160,000	16,000			
1080-1116	380 L.	do	175,000	16,000			
1116-1150	380 L.	do	145,000	15,000	972	112	70
1150-1183	380 L.	do	160,000	16,128	72,779	2,400	1,719
1183-1226	380 L.	do	160,000	16,000			
1840-2070	402 L.	Lowrance Bros	160,000				
2130-2230	403 L.	do	65,000				
3100-3125	434 L.	M. J. Roach & Co	143,000	12,348	[a] 93,586	5,419	3,542
3125-3156	434 L.	do	145,000	14,386	[b] 110,521	6,621	4,313
3156-3189	434 L.	do	142,165	14,467	[c] 156,632	6,640	5,060
3189-3229	434 L.	do	150,000	16,835	[d] 139,850	6,594	4,197
3229-3245 + 42a	434 L.	do	142,000	14,198	[e] 125,973	8,817	6,300

Stations.	Miles below Cairo.	Total scrapers.	Yards per team.	Yards per scraper.	Price per cubic yard.	Average height.	Average haul.	Kind of work.
					Cents.	*Feet.*	*Feet.*	
1038-1080	380 L.				13.89	15.3		New.
1080-1116	380 L.				13.89	16.7		Do.
1116-1150	380 L.	46	14	21	13.89	15.6	225	Do.
1150-1183	380 L.	1,101	42	66	13.89	17.7	250	Do.
1183-1226	380 L.				13.89	12.8		Do.
1840-2070	402 L.				18	18.5		Enlargement.
2130-2230	403 L.				17.9	17.3		Do.
3100-3125	434 L.	2,302	26	41	19.7	18.8	200	New.
3125-3156	434 L.	2,665	26	41	19.7	17.2	200	Do.
3156-3189	434 L.	3,146	31	50	19.7	17.2	200	Do.
3189-3229	434 L.	2,802	33	50	19.7	15.1	200	Do.
3229-3245 + 42a	434 L.	3,891	20	32	19.7	24.1	200	Do.

[a] 7,800 cubic yards paid for by Mississippi levee board.
[b] 9,448 cubic yards paid for by Mississippi levee board.
[c] 14,467 cubic yards paid for by Mississippi levee board.
[d] 14,104 cubic yards paid for by Mississippi levee board.
[e] 11,278 cubic yards paid for by Mississippi levee board.

Levee work in Lower Yazoo levee district below Greenville, May 1, 1902, to May 1, 1903.

Stations.	Miles below Cairo.	Contractor.	Cubic yards in contract, United States.	Cubic yards added by levee board.	Cubic yards placed during year.	Total laborers.	Total teams.
100-200	480 L.	Walker Stansell	60,000				
600-790	496 L.	do	100,000		3,509	158	106
1346-1730	500 L.	do	100,000	100,000			
1730-2108	505 L.	do	85,000	30,000	25,088	726	520
2572-2880	531 L.	Lowrance Bros	60,000	61,400	[a] 67,476	3,060	2,316
3800-3942	552 L.	L. C. Dulaney	105,000		24,565	1,308	864
4670-4725	567 L.	I. R. Bobbitt	134,500		125,683	6,455	5,098
4725-4780	568 L.	do	127,500		125,132	5,317	4,153
4780-4890	568 L.	Thos. Worthington	60,000				
4890-5000	569 L.	Donovan & Daley	75,000		21,520	1,166	801
5000-5170	570 L.	Morgan & McCarten	75,000				

[a] 31,871 cubic yards paid for by Mississippi levee board.

Levee work in Lower Yazoo levee district below Greenville, May 1, 1902, to May 1, 1903—Continued.

Stations.	Miles below Cairo.	Total scrapers.	Yards per team.	Yards per scraper.	Price per cubic yard.	Average height.	Average haul.	Kind of work.
					Cents.	*Feet.*	*Feet.*	
100-200	480 L.				15.74	15		Enlargement.
600-790	496 L.	64	33	55	15.74	12.1	200	Do.
1846-1730	500 L.				15.74	11.9		Banquette enlargement.
1730-2108	505 L.	348	48	73	15.74	6.2	225	Banquette.
2572-2880	531 L.	1,474	29	46	16.5	6.5	175	Do..
3800-3942	552 L.	594	28	41	19.87	16.8	200	Enlargement.
4670-4725	567 L.	3,238	25	39	15.95	12.1	175	New.
4725-4780	568 L.	2,656	30	47	16.7	12.8	175	Do.
4780-4890	568 L.				19.4	14.1		Enlargement.
4890-5000	569 L.	524	27	41	19.4	14.3	275	Do.
5000-5170	570 L.				19.875	13.2		Do.

Table showing levee construction by the Mississippi levee board, May 1, 1902, to May 1, 1903.

Stations.	Miles below Cairo.	Cubic yards in contract.	Cubic yards placed during year.	Price per cubic yard.	Extras paid.	Total expended.	Kind of work.
				Cents.			
0-260	365 L.	34,976	16,614	22		$3,106.82	Topping.
861-1016	380 L.	53,411	23,064	22	$378.42	4,629.01	Banquette.
861-1016	380 L.	5,331	506	22		94.62	Topping.
1016-1340	385 L.	16,000	311	22		58.16	Topping and enlargement
1340-1550	390 L.	122,143	50,020	22		9,353.74	Enlargement.
1380-1511	395 L.	52,947	13,822	22	756.84	3,228.03	Banquette.
2683-2853	415 L.	74,489	25,300	22		4,731.10	Do.
3100-3245	434 L.	72,234	57,157	19.7		10,418.94	Do.[a]
3410-3500	440 L.	86,026	16,378	22		3,062.69	Enlargement and banquette.
3500-3562	442 L.	78,379	31,830	22		5,952.21	Do.
3850-3981	455 L.	92,272	56,261	22		10,520.81	Enlargement.
3981-4150	475 L.	27,630	19,757	22		3,694.56	Topping.
4200-32	480 L.	107,000	62,669	22	17,426.36	26,531.51	Enlargement and banquette.
843-940	490 L.	106,866	50,714	22		9,483.52	Enlargement.
2572-2880	531 L.	61,400	31,871	16.5		4,732.84	Banquette.[a]
4013-4243	550 L.	90,000	26,147	22		4,889.49	Banquette.
Total		1,063,104	482,391		18,561.62	104,488.05	

[a] Work done under Government contract and paid for by levee board.

Rainfall at Greenville, Miss., from May 1, 1902, to May 1, 1903.

Months.	Rainfall, 1902-3.	Mean 1886-1903.	Months.	Rainfall, 1902-3.	Mean 1886-190
1902.	*Inches.*	*Inches.*	1903.	*Inches.*	*Inches.*
May	4.57	3.62	January	5.04	5.
June	.97	3.92	February	8.04	4.
July	2.13	4.32	March	5.76	5.
August	1.31	3.58	April	1.12	3.
September	5.46	2.90			
October	2.48	2.06	Total	48.48	47.
November	6.64	3.72			
December	4.96	3.82			

APPENDIX 3 C.

REPORT OF MR. E. C. TOLLINGER, ASSISTANT ENGINEER.

GREENVILLE, MISS., *May 10, 1903.*

CAPTAIN: I have the honor to submit the following report of operations in the Upper Tensas levee district from May 1, 1902, to May 1, 1903.

The limits of the district, together with a brief description of the location of the different systems, will be found in the Annual Report of the Chief of Engineers for 1900, pages 4854 and 4855. The only change to be noted is an extension of the Arkansas River system from stations 732 to 785 on the Dry Bayou location.

The total length of the levee in this district on May 1, 1902, was 186.7 miles, containing 28,579,718 cubic yards, 21,686,858 cubic yards being credited to the United States and the remaining 6,892,860 cubic yards to the local boards.

During the year there have been added by the United States 269,563 cubic yards and by the local boards 453,587 cubic yards, making a total for the year of 723,150 cubic yards. During the year 8,698 feet of new line have been constructed in Louisiana, throwing out 8,689 feet of old levee, containing 210,000 cubic yards, leaving the total length of the levee line in the district May 1, 1903, 186.7 miles, containing 29,092,868 cubic yards, 21,956,421 cubic yards being credited to the United States.

The construction of the Killarney Loop, in Louisiana (593 R.), stations 3914+84 to 4001+73, caused the throwing out of 8,689 feet of old levee containing 210,000 cubic yards.

At the close of the fiscal year 1902 all existing contracts had been completed.

During the past season the following pieces of work were put under contract:

Bids opened August 20, 1902.

Stations.	Miles below Cairo.	Awarded to—	Price.	Kind of work.
		In Arkansas.		
			Cents.	
2252-2533	486 R.	Lewis & Jennings	21.5	Enlargement.
3950-4080	515 R.	M. L. Linnan	16	Do.
4080-4210	516 R.	Donovan & Daley	19.7	Do.
		In Louisiana.		
190-256	523 R.	M. L. Linnan	17.48	Enlargement.

Bids opened February 12, 1903.

Stations.	Miles below Cairo.	Awarded to—	Price.	Kind of work.
		In Arkansas.		
			Cents.	
2087-2121	470 R.	Geo. R. Lacey	15.7	New work.
2121-2164	470 R.	Donovan & Daley	16	Do.
		In Louisiana.		
0-120	517 R.	Dulaney, Sessions & Leonard	19.74	Enlargement.
120-190	517 R.	Donovan & Daley	17.25	Do.

Weed cutting.—Bids for weed cutting on the entire line in Arkansas were opened on August 16, but, being considered too high, they were all rejected, and contracts were made with Mack Anderson and W. H. Lacey to do the work at 25 cents per station. Bids for the Louisiana work were opened on August 19, and were rejected on account of being to high. Contract was made with B. A. Stephany to cut the entire line at 33 cents per station.

ARKANSAS RIVER LEVEES.

On pages 4857 and 4858 of the Annual Report of the Chief of Engineers for 1900 will be found a brief description of the conditions and needs of the Arkansas River levees and the relation of this line of levees to the Mississippi River system.

No new contracts having been made during the season for the further extension of this line, the gap of 6.05 miles between the lower end of the Arkansas River system and the main line of levees at Boggy Bayou remains as it was in the last report. The safety and general good of the district demand the closing of this gap as rapidly as possible.

Bids were opened August 20, 1902, for a half-mile extension of this line, stations 783–809, but, being considered too high, were rejected.

CAVING BENDS.

Cypress Bend (*426 R.*).—The caving at Lucca Landing has moved down the bend from station 420. The old abandoned levee has caved off from stations 420 to 460. There has been some caving from stations 630 to 650, leaving about 400 feet between levee and river at the latter station. The most rapid caving during the high water was at the lower end of this bend, stations 730 to 750. The shore line here is about 600 feet from the levee. There does not seem to be any probability of the levee being in danger from the caving in this bend for at least two years.

Rowdy Bend (*451 R.*).—The shore line is within 600 feet of the levee at the angle at station 1530, and within 400 feet at station 1740. Caving has been very active near the latter point. but I do not consider that there is any danger of it reaching the levee this season.

Upper Leland (*470 R.*).—Caving continues on the upper side of this neck. A survey made on April 29 showed that an average of about 400 feet had caved off during the past year. This destroyed the old levee along this bank, which permitted the current to flow across the neck during the high water, destroying the spur levee on the south side of the neck, nearly causing a crevasse in the levee that it joined and threatening a cut-off across the neck. Projects for the protection of this neck have been submitted.

Matthews Bend (*509 R.*).—As the greatest amount of caving occurs when the river is at about bank-full stage, the results can not be accurately determined until it has fallen considerably below the present stage. It is closest to the levee at station 3728, where it is about 450 feet distant.

Wilsons Point (*532 R.*).—Although the levee is close to the river from stations 930 to 1206, I do not regard any of it as being in danger during the coming year, as there is no caving except between stations 930 and 960, and very little there.

Mascot (*576 R.*).—Caving has continued here and is now within 350 feet of the levee. A new loop will be required, as given in tabulated statement submitted herewith.

Reids (*604 R.*).—There are three points here at which the bank has caved to within 350 feet of the levee. There has been very little caving so far this season, but enough more is to be expected after the river returns to its banks to endanger the present levee. A new loop for this place has, therefore, been included in the tabulated statement.

CONDITION OF LEVEES WITH REFERENCE TO 1903 HIGH WATER.

In Arkansas.—Extension Arkansas River system, total length 14.8 miles:

1.2 per cent from 0.5 to 1.7 feet below 1903 high water.
33.0 per cent flush with 1903 high water.
50.0 per cent 0.2 foot above 1903 high water.
15.8 per cent 3.0 feet above 1903 high water.

Mississippi River System.—Costello Gin to Louisiana State line; length 83.3 miles:

1.0 per cent 3 feet above 1903 high water.
22.6 per cent 2 feet above 1903 high water.
36.2 per cent 1 foot above 1903 high water.
36.2 per cent 0.5 foot above 1903 high water.
4.0 per cent topped 1 foot above 1903 high water.
30.4 per cent has banquette.
69.6 per cent has no banquette.

In Louisiana.—Length of line from Arkansas State line to lower end of district, 88.6 miles.

9.1 per cent 5 feet above 1903 high water.
8.0 per cent 4 feet above 1903 high water.
10.0 per cent 3 feet above 1903 high water.
18.5 per cent 2 feet above 1903 high water.
25.7 per cent 1 foot above 1903 high water.
28.7 per cent 0.5 foot above 1903 high water.
57.5 per cent has banquette; 42.5 per cent has none.

Estimated yardage to bring the entire line to a grade of 3 feet above high water of 1897, with standard section.

Stations.	Enlargement.	New levee.	Banquette.	Total.	Remarks.
In Arkansas.	*Cu. yds.*	*Cu. yds.*	*Cu. yds.*	*Cu. yds.*	
0-783[a]	365,490		198,009	563,499	Enlargement of Arkansas River levees.
783-1087		1,187,429	153,287	1,340,716	Extension Arkansas River levees.
0-269 0-4210			1,057,143	1,057,143	Amos Bayou. Main line.
Total	365,490	1,187,429	1,408,439	2,961,358	
In Louisiana.					
0-4619		[b] 665,000	883,403	1,548,403	
Grand total	365,490	1,852,429	2,291,842	4,509,761	

[a] Stations 655-783 built to 3-foot grade without banquette.
[b] New loops at Mascot and Biggs, La.

Estimate for ultimate Commission grade.—This is based on the average height of new Commission grade at White River and Arkansas City, Arkansas City and Greenville, Greenville and Lake Providence, and Lake Providence and Vicksburg, and applying these averages to the local high water along the line between these respective points, thus giving the following approximate estimates in Arkansas and Louisiana:

Stations.	Kind of work.	Cubic yards.	Price.	Total cost.	Remarks.
	In Arkansas.		*Cents.*		
0-655	Enlargement	1,066,015	18.8	$200,410.82	Arkansas River levees.
655-783	do	184,000	18.8	34,592.00	Do.
783-1087	New levee	1,826,044	20	365,208.80	Do.
0-1087	Banquette	688,635	15	103,295.25	Do.
Total		3,764,694		703,506.87	
0-269 0-4210	Enlargement	4,928,666	18.8	926,589.21	Ames Bayou line. Main line.
600-816	New levee	1,249,279	16	199,884.64	Covers 600-900.
2087-2164	do	422,100	16	67,536.00	Covers 2087-2176.
0-4210	Banquette	1,756,165	15	263,424.75	
Total		8,356,210		1,457,434.60	
	In Louisiana.				
0-4619	Enlargement	6,286,203	18.8	1,181,806.16	
0-4619	Banquette	2,107,220	15	316,083.00	
1806-1855	New levee	284,000	17	48,280.00	Covers 1810-1840 (Hollybrook crevasse).
Total		8,677,423		1,546,169.16	

SUMMARY.

	Cubic yards.
Extension and enlargement of Arkansas River levees	3,764,694
Arkansas main line	8,356,210
Louisiana	8,677,423
Total cubic yards	20,798,327
Total cost	$3,707,110.63

NOTE.—The above estimate has been corrected to agree with survey of 1901-2, after deducting 289,563 cubic yards in Arkansas and 302,351 cubic yards in Louisiana, placed since survey was made: also allowing for the Hollybrook crevasse.

The estimates show that there is still required 365,490 cubic yards to bring the Arkansas River levees from stations 0 to 783 up to the 3-foot grade with standard section, 1,187,429 cubic yards for the extension of this levee to station 1087 on

Cypress Creek opposite station 81 on the main line, and 351,296 cubic yards for banquette for the above stretches of levee from Red Fork to Cypress Creek; leaving 1,940,000 cubic yards to cover the main line in Arkansas and Louisiana, and 665,000 cubic yards for the new loops at Mascot and Biggs, La.

ARKANSAS RIVER LEVEE IMPROVEMENT.

The Arkansas levees in the Red Fork levee district extend from the Lincoln-Desha county line to the beginning of the Government levee just below Red Fork, having a length of about 14 miles.

The levee board of that district have sold their lands and improved their levees, giving them a grade 3 feet above the highest known water previous to 1903, with 6-foot crown and 2½-to-1 slopes, except that on the higher levees generally an 8-foot crown and 3-to-1 slopes have been used. On Fish Trap loop, 2,000 feet long, an 8-foot crown and 4-to-1 slopes were used. During the past year 351,997 cubic yards have been placed, making a total for the past three years of 454,805 cubic yards. The high water of 1903 ranged from 1.2 to 3 feet below this grade.

HIGH WATER OF 1903.

The high water of 1903 has been the highest known water in the district with the exception of 20 miles of the lower end. The following table shows the maximum gage readings from Cairo to Vicksburg for the years 1897, 1898, and 1903, with comparison between the maximum heights attained and the time intervals between the dates of highest water at Cairo and at the other points mentioned:

Gauge stations.	1897.			1898.			1903.		
	Height.	Date.	Days from Cairo.	Height.	Date.	Days from Cairo.	Height.	Date.	Days from Cairo.
	Feet.			*Feet.*			*Feet.*		
Cairo	51.7	Mar. 25	....	49.8	Apr. 6	....	50.6	Mar. 16	....
Memphis	37.6	Mar. 20	5	37.6	Apr. 10	4	40.1	Mar. 20	4
Helena	51.8	Apr. 4	10	49.1	Apr. 17	11	51	Mar. 25	9
Sunflower	47.2	....	....	46	....	....	....	....	....
Mouth White River	52.4	....	....	51.5	....	....	....	....	....
Arkansas City	51.9	Mar. 29	4	51.1	Apr. 19	13	53	Mar. 27	11
Greenville	46.7	...do...	4	46.2	Apr. 21	15	49.1	...do...	11
Lake Providence	44.5	Mar. 30	5	44.4	Apr. 23	17	46.5	...do...	11
Vicksburg	52.5	Apr. 16	22	49.4	Apr. 24	18	51.8	...do...	11

Gauge stations.	Compared with 1897.				Compared with 1898.	
	1898.		1903.		1903.	
	Height.	Days from Cairo.	Height.	Days from Cairo.	Height.	Days from Cairo.
	Feet.		*Feet.*		*Feet.*	
Cairo	−1.9	....	−1.1	....	0.8	....
Memphis	0	−1	2.5	−1	2.5	....
Helena	−2.7	1	.8	−1	1.9	−2
Sunflower	−1.2	....	....	....	....	....
Mouth White River	− .9	....	....	....	....	....
Arkansas City	− .8	9	1.1	7	1.9	−2
Greenville	− .5	11	2.4	7	2.9	−4
Lake Providence	− .1	12	2	6	2.1	−6
Vicksburg	−3.1	−4	− .7	−11	2.4	−7

Crevasses occurred in Mississippi on March 27, and on that account this was the date of the maximum stage of the river from Arkansas City to Vicksburg. The crevasse at Hollybrook, La., occurred on April 3.

Before studying the comparison with the flood of 1897, it must be noted that the crevasses in the levees on the St. Francis front for that year were located above Memphis and occurred from March 14 to 24, and the water that passed through these crevasses returned to the river a few miles above Helena. These facts will explain the apparent anomaly of the maximum stage being reached at Memphis earlier than at Cairo, and at Arkansas City earlier than at Helena.

The maximum gauge readings of 1903, when compared with those of 1897, show great irregularity in the differences, but when compared with those of 1898 give much more nearly uniform results. This may be explained by the fact that the crevasses from Helena down did not occur until the flood had more nearly reached its limit than was the case in 1897, and, therefore, would more nearly parallel the slopes of a confined river, as in the case of the high water of 1898.

The maximum stages for 1903 show great changes at Memphis and Greenville. That at Memphis is evidently owing to the additional levees on the Arkansas side of the river, and, especially, the additional railroad embankment between that levee and the river. That at Greenville may be due to changes in the direction of the high-water currents, which may be partly incident to the higher stage of the water, but much more likely belong to the long line of changes started by the destruction of the old levees in front of the Huntington Short Line levee. On the other hand, these changes in the high-water currents may have lowered the maximum reading at Arkansas City, instead of raising it as at Greenville.

High-water marks established 1,000 feet to half a mile apart show that the slopes of the river are very broken, and that the slopes for different high waters are far from being parallel or from having even a uniform divergence. In regard to the Vicksburg stage in 1897, it should be noted that the overflow water from the Yazoo Basin returned to the river at Vicksburg, giving it at that point much of the height that it would have attained had there been no crevasses from the river into the basin.

The comparisons made in the foregoing table seem to point to the conclusion that the 1903 high water furnished a safer guide for grades than any previous high water, but that some allowance should be made for the additional rise that would have taken place between Greenville and Vicksburg had there been no crevasse.

Wind.—The absence of any windstorm during this high water was a very favorable as well as a very unusual circumstance.

Sickness of engineer officer.—We all regretted the necessity of our officer, Capt. Chas. L. Potter, having to undergo a surgical operation, and especially that it should happen at such a time as to confine him to his room during this high water. My experience, which covers all the high waters occurring in the Third district during the past twenty years, has convinced me that the presence of the engineer officer at such times is a very great advantage, and would have been especially so in this high water, which is the only one in which we have had no Government funds for the work.

Organization.—At a meeting of the United States Engineers and the local levee boards working in Arkansas, for the purpose of organizing for high-water work, it was agreed that the Red Fork levee board should have supervision on the Arkansas River above Red Fork, and that the United States Engineers should have general supervision over all the work on the Arkansas River levees below Red Fork and over all the work in the Upper Tensas district in Arkansas.

The levee line was then divided into sections and placed under employees reporting to this office. Inspector T. S. Shields was given special charge of all work on the main line above station 1510 (Gaines Landing, 450 R). Inspector P. L. Lowe was placed in charge of this office (Greenville, Miss.), and Inspector John J. Hoopes was transferred from Sterling on March 12 to assist Mr. Lowe.

At a meeting at Vicksburg with J. T. McClellan, president of the Fifth Louisiana levee board, it was decided that inasmuch as the Government had no funds, but only plant and some sacks, the board would assume all responsibility for the work in the Upper Tensas levee district in Louisiana except that of establishing high-water marks and ascertaining flood limits. After the crevasse at Hollybrook, however, I sent him, at his request, three experienced employees, who were employed on special work.

Barges, sacks, etc., were all distributed before the rise reached its maximum stage. Two steamboats were also placed at the disposal of the board, as noted elsewhere in this report.

Division of the work.—Very naturally this high-water protection work was divided into three distinct divisions. On the Arkansas River it was done by the Red Fork levee board; in the Upper Tensas district in Arkansas by the Desha and Tensas Basin levee boards in the upper end and the Chicot County levee board in the lower end, and by the Fifth Louisiana levee board in the Upper Tensas district in Louisiana. A statement of the expenditures of these districts, which includes those for high-water protection, accompanies this report.

Assistance by protected interests.—The planters in the vicinity, several lumber companies, and the Missouri Pacific Railway Company sent men freely to the work. In one emergency an additional force of 300 or 400 men was obtained at very short notice. The railway company transported men and material for the work free of charge and ran special trains to facilitate delivery.

Funds.—The Government funds available for high-water protection work being very limited, the expense of same was borne by the local levee districts, the exception being the payment by the Government of $1,293.24 for labor on the Arkansas River levees.

Material and plant.—The sacks on hand at the United States fleet at Greenville were used on this work, 76,000 being used in this subdistrict, of which number 11,000 were used on the Arkansas River levees and 65,000 on the main line in Arkansas. The Government also furnished quarterboats, wheelbarrows, shovels, etc., that it had on hand, which were distributed as directed.

Steamboats.—United States steamboats were employed in the distribution of these quarterboats and supplies, and other work in which they could be used to advantage. The steamer *Meter* was used a few days at Leland; the steamers *Vedette* and *Arthur Hider* were used in distributing barges, etc., and the steamers *Columbia* and *Florence* were transferred from the Vicksburg district and used in Louisiana, the Fifth Louisiana levee district paying the crew of the *Florence* to March 31. In addition to these, the Tensas Basin levee board chartered the steamer *Providence*, the Chicot County board chartered the gasoline launch *France* and the steamer *Gate City* was chartered by the Fifth Louisiana levee board.

High water, Arkansas River levees.—The levee from Lincoln County line to Red Fork (stations 0 to 730+50), which had been built by the Red Fork levee district and later raised and enlarged by them, was taken care of during the high water by that district, the Government furnishing them with 4,000 sacks. This levee is 3 feet above high water of 1897. The present flood reached to about the same stage at the county line as in 1897, and about 1.8 feet higher at Red Fork than the 1897 high water.

An alarming situation was caused by holding an old front levee at Fletchers (stations 492–533) until the water reached its top, which resulted in the new levee being very much damaged and even threatened with destruction from the sudden impact of the flood wave caused by the failure of the front levee.

Great trouble was experienced between Fletchers and Red Fork (stations 533 to 730+50). This part of the line had been enlarged on the land side, which was the cause of a great deal of sloughing.

The expenditures by this board on this protection work amounted to $1,908.21, of which $969.44 was for labor and the remainder for materials and incidentals. From Red Fork to the end of the levee (stations 0 to 783) the Government, which had built this part of the levee, paid for labor to the amount of $1,293.24, and furnished about 7,000 sacks.

From station 0 to 655 the water stood at the top of two-fifths of this length of levee and within 0.2 of a foot of the top of the remainder. From stations 655 to 783 the top of the levee was about 3 feet above this high water, except from stations 680 to 704, where it is quite low, 1,000 feet, stations 694 to 704 being 0.5 of a foot to 1.7 feet below the flood plane. This levee was very much saturated and could not have been held if the river had risen one-fourth of a foot higher.

At Red Fork the maximum stage of the river was 1.8 feet above that of 1897, while that of the backwater behind this levee was only two-tenths of a foot higher than then, showing a reduction of 1.6 feet in the height of backwater at this point, caused by the extension of the levee from stations 655 to 783. This extension is across a very wide, deep bottom, over which a large body of water flowed, flanking the levees. This high water has shown very plainly that the work of raising and enlarging the levee from stations 0 to 665 to a grade 3 feet above high water of 1903 is more urgently needed than a further extension of the line. It has shown, too, that the main-line levees should be raised and enlarged before the gap between the Arkansas River line and the main line is closed or even reduced more than 25 or 30 per cent. It has also shown that if the Arkansas River levees be extended the extension should have a grade throughout as high or higher than the grade at the present end of the line, station 783.

Upper Tensas district in Arkansas.—The work done and material used on this part of the levee will be found in a table appended to this report. Especial consideration is given to the situation at Leland Neck and Vaucluse, as follows:

Leland Neck (470–483 R).—The distance across this neck is only 3,000 feet, while the distance around the point, as traversed by the river, is 13 miles. The difference in elevation of the surface of the water at the two sides was 4.7 feet, and there is no undergrowth to check the flow of the water across the neck. In 1897–98 the present short-line levee was built on account of the old levee beyond it (toward the end of the point) being in danger of caving into the river. The old levee was left in place to prevent a current from flowing across. Up to a year ago 2,000 feet of this levee had caved off. It was then evident that the levee on the lower side, being very low, would either have to be removed or raised and enlarged to serve as a spur. Owing to the want of funds, it was determined to raise 1,000 feet of the spur and remove the remaining 1,600 feet, all of which was done. It soon became evident, from the terrific cross current at the end, that this spur would be very hard to maintain during this high water. Several days before the river reached the maximum stage a soft place in the formation near the outer end was washed out, caving started, and continued rapidily toward the main levee, accompanied by the formation of a deep cut at its end as it receded, which added to the difficulty of protecting the end of the spur. This cut extended laterally, forming a very dangerous channel which threatened the main line. It can not be doubted that, had the river remained within 2 feet of the maximum stage for a few days longer, there would have been a cut-off here during this high water.

It was only by the greatest effort that the end of the spur next to the main levee and the main levee itself were prevented from caving in, and a crevasse, with the consequent overflow, averted. Had it not been for the supply of rock belonging to the Government, which was used in holding the levee, all our efforts would have ended in failure.

The most critical time was just after the crevasse had occurred at Lagrange, Miss., nearly opposite this point. This was on March 27, at 11 a. m. The rock for the work was being loaded at Greenville by men who were living at the latter place. This force was panic-stricken by the crevasse and stopped work at once. The tug *Parker*, which was delivering the rock, and the steamer *Meter*, which was placing it, were withdrawn at once, to be used at the crevasse. Before the force could be reorganized nearly all that remained of the dike had been destroyed. As soon as it was possible to do so, a force of loaders were taken from the Arkansas side, and a boat obtained to continue delivering and placing the rock, and the caving held in check.

On May 5, when the Greenville gauge read 39.5, there was 3.5 feet of water over the upper shore line. A channel has been scoured a portion of the distance across the neck, and will continue to lengthen until the water has fallen about 3 feet more.

Surveys have been made for the purpose of locating a spur, which is intended to prevent a cut-off. It is probable that the upper side of the neck will have to be revetted at some future time. Blueprints showing the results of these surveys have been forwarded to your office.

Vaucluse (*487 R.*).—At Vaucluse there were dangerous boils on the east bank of the old bed of Lake Chicot. These developed on March 4, and were regarded as dangerous until after the river stopped rising, notwithstanding the fact that a large force was kept constantly at work on them.

On account of the peculiarity of the situation and of the large amount of work done here, this was made the subject of a special report, which is now on file in your office.

Upper Tensas district in Louisiana.—A table is appended showing work done and material used on this part of the line.

Hollybrook Crevasse (*547 R.*).—The levee broke at Station 1825 of the Louisiana line at 7 a. m., April 3, after the river had fallen 2.3 feet, or 0.1 foot below the 1897 high water, and caused a fall of 1.5 feet in the river at Lake Providence, 6 miles above, in twenty-four hours. At that time the danger was considered as being about over. All the forces except the watchman had gone. The part of the levee that broke appeared to be in good condition, and watchmen had been previously instructed to give their attention to other portions which did not seem so secure.

After the crevasse had widened to 3,000 feet the ends were secured by brush and sacks, holding the break to that width. Thirty men were employed two days on the upper end and 35 men two and one-half days on the lower end in doing this work, and three coils of five-eighths-inch wire cable were used. No effort was made to close this crevasse, but as the board officials believed that the cutting off of 1 foot of the depth of the flow through the crevasse would mean the protection of several thousand acres of improved land from overflow, they set about accomplishing this object by cutting down trees around the outside of the crevasse and lodging them against trees standing nearer the intake. This required 60 men working four days.

This levee was built in 1877–78 with wheelbarrows. It was raised and enlarged in 1893–94 and again in 1898–99, the latter enlargement being on the land side. All work on it has been done by the State of Louisiana and the Fifth Louisiana levee district.

The statements of different eye witnesses agree that the leak which caused the break occurred about half way between the crown and banquette. At first I was inclined to the opinion that the break was caused by the bad bond between the old levee and the 1898–99 enlargement. There are other things, however, that may have caused it. A landside enlargement is always liable to give trouble, and may have been the prime factor in this case. At the time this levee was buil stumps were never removed from the foundation of levees, and large boxes use in building of wheelbarrow runways were often left in the levee. Stumps tha very likely were left in this foundation may have rotted by this time, leaving hole which the water entered and enlarged, thereby weakening the levee.

High-water marks.—Boat spikes, ⅜ by 7 inches, stamped "03," mark the hig water of 1903. These have been connected with the stone line benches, and the elevations and locations recorded with great accuracy, and can therefore b regarded as bench marks of this line.

Flood limits.—The water passing around the head of the main levees cover practically the same ground as in 1897, an area of about 500 square miles, but th water was from one-half to one foot shallower than in that year, in places, due t local causes.

The water from the Hollybrook Crevasse, in Louisiana, covered a strip of lan about 15 miles wide and 45 miles long, containing about 675 square miles. The are shown on the high-water map which accompanies these reports.

Lessons from the high water.—This flood has confirmed what had been full established, in the minds of levee engineers, by the previous floods.

Specifications.—The strict enforcement of present specifications, with perhap some slight modifications hereinafter mentioned, would give a very efficient sy tem of levees when completed to the necessary grade.

Standard section.—The standard section appears to stand the test very wel generally. Where the levees must he built with poor material, however, flatte slopes would be required, some very silty material requiring probably as much a a 1 on 6 slope on the land side.

Banquette.—In asserting my continued confidence in the present standard se tion, I assume that the higher levees are to have a banquette behind them. The banquettes should have, in general, a crown 30 feet wide, a 1 on 10 crown slope, a on 5 rear slope, and a grade 5 feet below 1903 high water. Where boils ha shown up behind the levees during high water, a still wider banquette would b desirable. In new levees the banquette should be built with the levee.

Grades.—Although the slope of any one high water is never parallel to that o any other, the slope assumed by the highest water, in the more nearly confin river, may be regarded as being the more nearly parallel to the ultimate hig water, wholly confined, that may be expected at some future time. Grades bas on the high-water marks of 1903, therefore, would seem to be a better guide tha those of 1897.

If funds are not available for raising and enlarging the levees to 3 feet abov 1903 high water, I would recommend that a grade 2 feet above it be adopted.

Muck ditch.—A muck ditch of dimensions now used, running 104 cubic yards to the station, should be excavated under every new levee built, and often under enlargements of old levees.

Borrow pits.—Where the current along the levee in high water will be rapid, care should be taken to leave the borrow pits in good shape. No logs, stumps, knolls, or traverses should be left, either on the berm or in the pits, within 100 feet of the foot of the slope of the levee. In extreme cases it would be better to require the borrow pits to be made on the land side.

Cutting trees, etc.—Trees, great and small, within 100 feet of the toe of the slope of levee on each side, are now cut down, so that they will not shade the levee. By cutting and removing all trees, stumps, and logs from the berm on the river side of the levee, so that only stumps less than one-half foot in height would remain, other benefits would be derived. The flow of water along the levee would not be obstructed and would not, therefore, be so liable to scour the slope of the levee. The moving of barges along the levee in high-water protection work, especially when done by a steamboat, as in the recent high water, would be less interfered with.

On the land side, besides cutting the trees, the ground should be cleared of brush and undergrowth, and logs removed, in order that the sun may keep the ground as dry as possible; that the drainage of the seep water from the levee may be obstructed as little as possible, and that the grass may extend over the ground (whether by planting or by spreading from the levee) and form a good sod.

This would have the further advantage of attracting cattle and sheep to range over the cleared portion, which would be beneficial at all times except during high water.

Land side enlargement.—No levee should be enlarged on the land side if it can possibly be avoided. Nearly all the sloughing that occurred in this district during this high water was where the levee had been enlarged on the land side.

Travel, etc.—The policy of not allowing any funds of the United States to be used for the improvement of any levee that has been abused by travel or depredations of stock is just and right and should be continued.

Drainage.—Whatever can be done to drain water from the levee on the land side by seep ditches, etc., should be done.

The general drainage of the country would be a great benefit to the levees, and any movement to this end should be heartily welcomed. The new drainage law in Arkansas may be the beginning of such a movement. When our levees shall have been raised and enlarged to the extent that the gap between the Arkansas River levees and the main line can be safely closed, this question of drainage will be a very important one, including, as it then will, the closing of Cypress Creek and opening Boggy Bayou.

Holding old levees intact.—An old levee in front of a new one should never be allowed to remain intact, for when a high water breaks through the old one the new one is endangered by the resulting rush of the water against it.

High-water funds.—The appropriation by the United States of a fund for high-water operations that would be sufficient for that work, without having to call on the levee districts for any additional sums, would insure a more complete control by the engineers, a more thorough organizátion, and better methods, all of which would result in the saving of a large amount of money for later construction work.

Later rise in the river.—The story of a very remarkable rise in the river is shown by the following table:

Date.	Cairo.	Memphis.	Helena.	Arkansas City.	Greenville.	Vicksburg.	
March 16	50.6	39.1	47.2	50.4	45.4	48.8	Maximum at Cairo.
March 20	50.1	40.1	49.4	51.9	47.6	49.9	Maximum at Memphis.
March 25	47.2	39.1	51	52.7	48.8	51.4	Maximum at Helena.
March 27	45	38.5	51	53	49.1	51.8	Meximum at Arkansas City, Greenville, and Vicksburg.
April 10	36	29.4	44	49.5	43.6	50.1	Minimum at Cairo.
April 13	37.6	28.5	42.2	48.2	42.5	49.4	Minimum at Memphis.
April 16	42.1	29.1	41.1	46.9	41.2	48.5	Minimum at Helena.
April 23	45.2	33	42.7	45.2	39.4	46.5	Maximum at Cairo.
April 27	43.9	34	43.8	45.1	39.2	45.8	Minimum at Arkansas City and Greenville.
April 30	40.1	34.4	44.4	45.3	39.5	45.1	Maximum at Memphis and Helena.
May 4	31.4	31.7	43.9	45.5	39.7	44.9	Minimum at Vicksburg; maximum at Arkansas City and Greenville.
May 5	29.8	29.6	43.1	45.5	39.7	44.9	Maximum at Vicksburg; standing at Arkansas City, Greenville, and Vicksburg.
	14.6	11.6	9.9	7.9	9.9	6.9	First fall after high water.
	9.2	5.9	3.3	.4	.5	0	Subsequent rise.

We here have a rise of 9.2 feet at Cairo, causing a rise of only two-tenths of a foot at Arkansas City and three-tenths of a foot at Greenville and no change at Vicksburg. This is explained partly and perhaps wholly by the preceding fall at Cairo being 14.6 feet, while at Arkansas City and Greenville it was only 7.8 feet and 9.9 feet, respectively. This would suggest that the rise served to fill out the slope between Cairo and Arkansas City to its normal flood slope. It would also suggest that this flood wave by flattening out as it passed down the river expended much of itself in arresting the fall at the lower points named.

Another peculiar aspect of this rise was its following so closely behind the high water of the season, reaching Arkansas City and Greenville before the river had gotten well within its banks in the vicinity of these stations.

MISCELLANEOUS.

The Memphis, Helena and Louisiana Railway, to extend from West Memphis, Ark., to Clayton, La., and which will form a part of the Missouri Pacific system, is now under construction. Track laying is about completed from Trippe, Ark., to Lake Providence, La., and grading has been started between Trippe and the north end of this district. This line enters the protected district from the north just below Red Fork on the Arkansas River, crosses the unprotected region back of the gap between the two systems, crosses the Amos Bayou line near the head of the main system, and runs through the entire district, touching at Trippe, Lake Village, Lake Providence, Stamboul, and Tallulah.

The same company (M., H. & L. Rwy. Co.) is making surveys for branch lines or loops through this delta country for feeders for its main line.

The St. Louis and San Francisco Railroad Company is making a survey for a line along the west bank of the Mississippi generally from St. Louis to the Gulf of Mexico.

The Rock Island system, too, has been surveying a line, having Vicksburg as an objective point. The revenues accruing from these enterprises, together with the increased revenue due to the development of the hitherto virgin lands of this most fertile valley, will be a very substantial and gratifying encouragement to the levee interest.

The Valley Telephone Company laid a submarine cable across the river this year, connecting Greenville with the telephone system in Arkansas. An accident to this cable, happening during the high water, prevented this office from being benefited by the system during that critical period. The forces along the levee, however, were benefited by this system intact in Arkansas.

Inclosed with this report will be found the following:

List of expenditures by the United States.[a]

Statement of work done and funds expended by the Red Fork, Desha County, Chicot County, Tensas Basin, and Fifth Louisiana levee boards and the State of Louisiana.

Table showing cost of construction.[a]

Labor statement.

In conclusion I wish to thank the local levee boards for prompt and efficient cooperation, and my assistants generally for faithful and thorough performance of duty.

Very respectfully,

E. C. Tollinger,
United States Assistant Engineer.

Capt. Chas. L. Potter,
Corps of Engineers, U. S. Army.

High-water operations in Upper Tensas levee district.

IN ARKANSAS.

Stations.	Below Cairo (R. B.).	Number sacks used.	Lumber used.	Remarks.
	Miles.		*Ft. B. M.*	
0-260				Amos Bayou levee; stood well above water; nothing done.
190-220	408	1,500		Main line; sand boils hooped.
630-750	432	3,000	2,000	Sand boils hooped.
880-940	438	3,500		Used in weighting brush to prevent sloughing and topping station 900-905.
1020-1240	441	16,000	2,000	11,000 used in topping; 4,000 used in preventing sloughs.
1510-1530	450	2,000		Used in sacking sand boils.
1663	451	80		Sand boil toe of slope
1709	451	50		Sand boil 30 feet from toe of slope.
1780	452	250		Sacking spur of old levee.
1831	466	50		Sand boil.
1834	466	90		Do.
1896-1898	467	575		Levee topped.
1939	467	30		Stump hole in banquette.
1967	467	45		Soft place at toe of slope.
2186	483	30,000	20,000	Leland.
2433	486	30		Stump hole.
2533	487	29,000		Vaucluse; sand boils in bed of lake
2604	488	125		Sand boil 20 feet from toe of slope.
3033-3088	495	600		Topping.
3134	497	228		Two sand boils.
3135	497	495		Three sand boils.
3468	505	175		One sand boil.
3490-3498	506	1,745		Topping.
3498-3499	506			Planked and sacked.
3498	506	50		Sand boil.
3499	506	95		Do.
3728	509	45		Do

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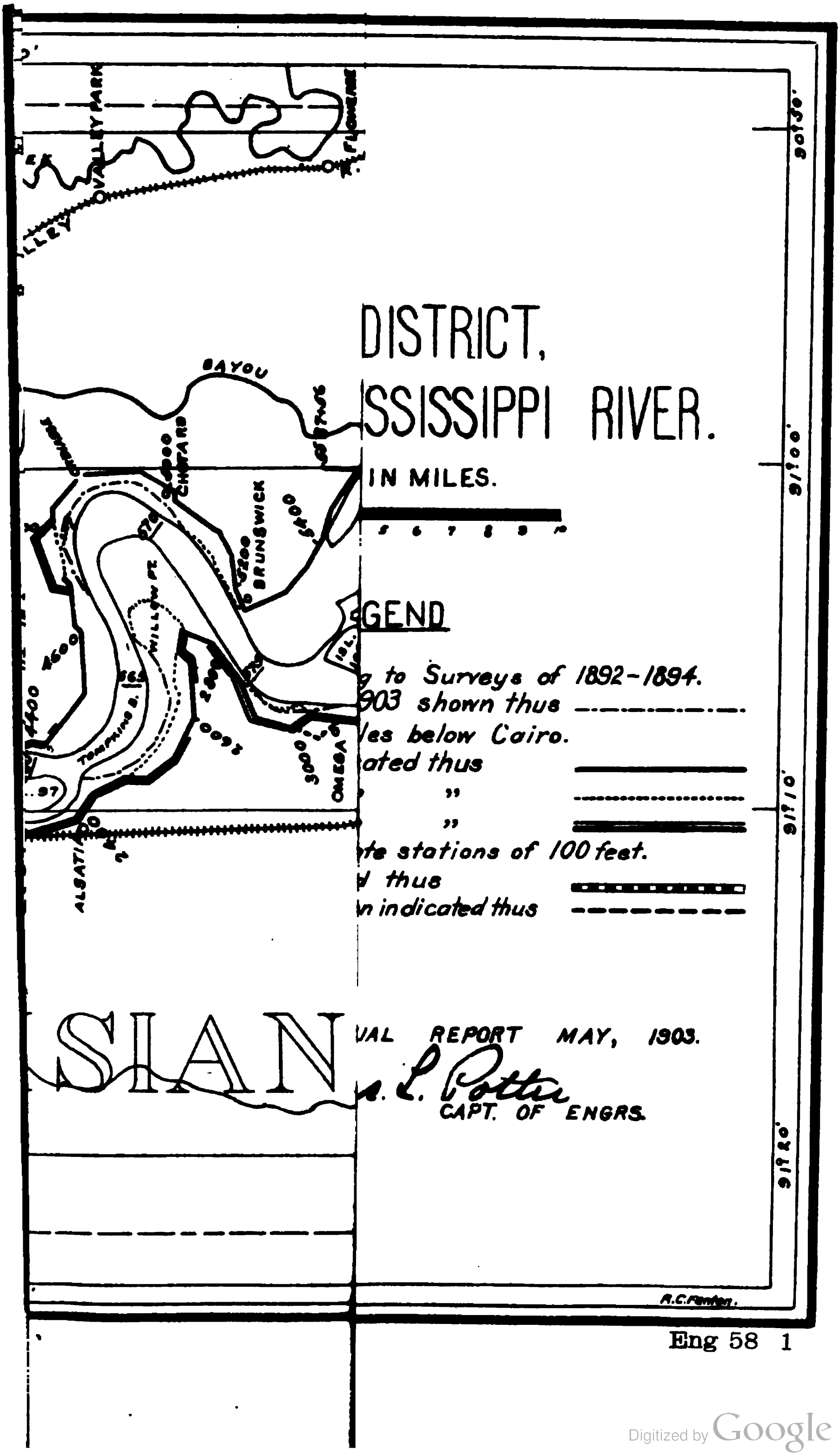
[a] Omitted.



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UAL REPORT MAY, 1903.

s. L. Potter
CAPT. OF ENGRS.

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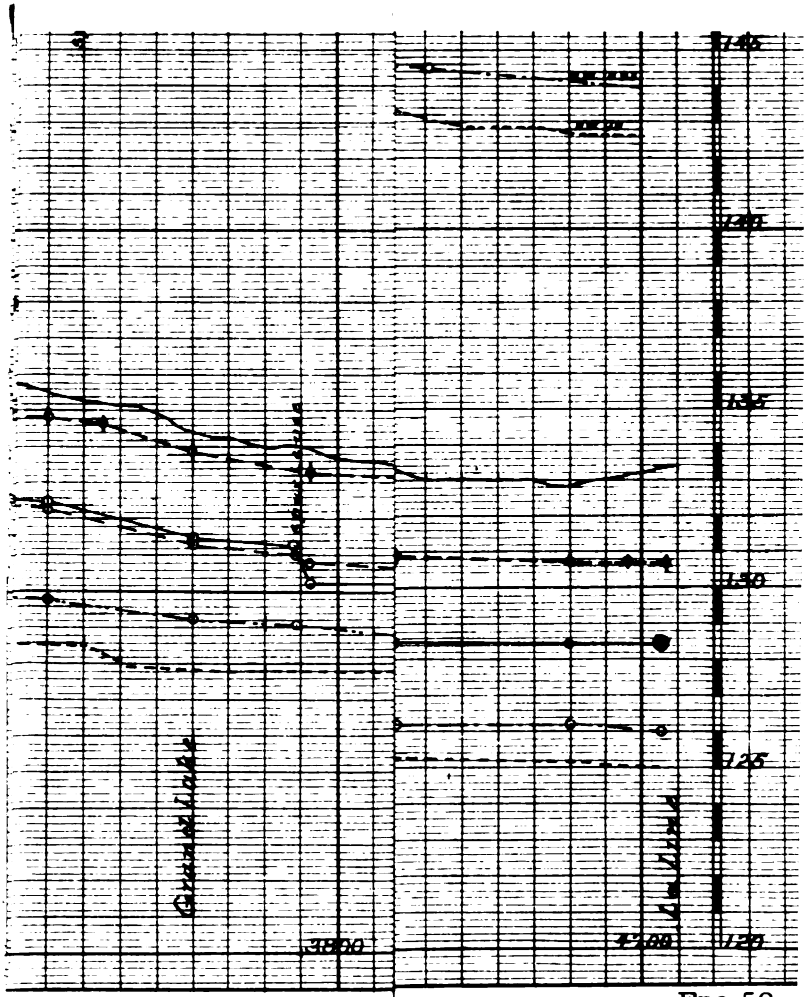

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High-water operations in Upper Tensas levee district—Continued.

IN ARKANSAS—Continued.

Stations.	Below Cairo (R. B.)	Number sacks used.	Lumber used.	Remarks.
	Miles.		*Ft.B.M.*	
3750-3758	509			Crown planked and sacked and supported with earth behind.
3758-3761	509			Planked ready for earth when La Grange crevasse occurred.
3761-3767	509			Planked and sacked. This stretch spans Grand Lake.
3767-3788	510			Planked and backed up with loose earth.
3788-3821	511			Lumber distributed in case of need.
3821-3830	511			Planked ready to be backed up with earth.
3830-3870	512			Planked and supported with loose earth.
3870-3883	512			Nothing done.
3883-3885	512			Planked and supported with earth behind.
3885-3898	512			Nothing required.
3898-3903	512			Planked and supported with loose earth behind.
3903-3916	513			Nothing done.
3920-3930	513			Planked only.
3930-3948	514			Planked, but not reenforced. Earth could not be obtained on account of seepage.
3948-3950	514			Sacked.
4080-4210	516			This section under contract; some gaps not completed which were sacked.
3930-3948	514			Only place where necessary to use land side crown to obtain earth.
3750-3950	512			Protected against wave wash.
3923	513			Small slough sacked.
3925	513			Boil hooped.
3928	513			Small slough sacked.
3934	514			Boil 8 feet from toe of slope hooped.
3938-3939	514			Several boils from 5 to 15 feet from toe of slope, which gave trouble, were hooped.
3939-3950	514			Nothing required.
3987	515			Willow Lake. Several sand boils, many of which were threatening and had to be hooped.
4092-4096	516			Lower part of slope very wet and soft; brush and sacks used along toe.
4104-4106	516			Slough at toe of slope; strengthened with brush and sacks.
3750-4210	516	19,500	21,000	Totals between these stations.
Total used		109,258	45,000	

NOTE.—Total sacks furnished, 133,000, of which United States furnished 65,000. There are remaining in hands of Chicot Levee board about 24,000.

IN LOUISIANA.

Stations.	Below Cairo (R. B.).	Number sacks used.	Lumber used.	Remarks.
	Miles.		*Ft. B. M.*	
1	519	300		Sloughed above banquette; planked and sacked.
1-16	519	2,000	1,800	Planked and sacked.
16	519	300		Sloughed above banquette.
16-19	519	2,200		Do.
22-35	519	1,190	2,000	Sacked and planked.
35	519	140		Sloughed above banquette.
35-70	520	3,000	5,000	Planked and sacked.
70	521	250		Sloughed above banquette.
71-190	522	20,940	10,050	Planked and sacked.
205	523	160		Sloughed above banquette.
205-390	530	12,580	25,000	Planked and sacked.
411-450	530	2,500	8,000	Do.
506	530	350		Slough on land side.
563-801	530	10,950	15,300	Planked and sacked.
901-902	531	10,000		Defect (trunk hole) appeared in banquette, almost causing crevasse.
908	531	1,000		Boil on land side.
915-925	531	1,178		Crown sacked.
925	531	800		Banquette sacked.
928-930	531	450		Crown sacked.
937-938	532	100		Base of levee sacked.
1160-1190	537	1,670	5,900	Planked and sacked.
1187-1288	538	380		On top of levee in places.
1203	539	600		Boil at toe of banquette.

High-water operations in Upper Tensas levee district—Continued.

IN LOUISIANA—Continued.

Stations.	Below Cairo (R. B.)	Number sacks used.	Lumber used.	Remarks.
	Miles.		*Ft. B. M.*	
1205-1337	540	5,440		Crown of levee sacked.
1337-1355	540	3,600	10,200	Planked and sacked.
1355-1458	541	8,400	1,000	Crown sacked and a few plank used.
1459	542	1,000		Crown of spur levee sacked.
1685-1952	547	11,880	1,800	Crown sacked; 1,000 linear feet planked.
2275	560	200		Boil on river side slope hooped.
2410-2418	562	1,470	1,800	Planked and sacked.
2478-2488	564	2,320	2,200	Do.
2500-2700	565	6,900		Old Salem levee, in front new loop.
2748	567	175		Protecting angle, river side.
2925	576	475		Soft place toe of slope and slough.
2881-2950	575		19,000	Planked; bagging put on plank; all reenforce with loose earth.
2950	576	300		Slough on land side.
2970-2978	576		2,400	Planked; bagging put on plank; all reenforce with loose earth.
2995	576	100		Slough on land side slope.
3005-3014	576		2,700	Planked; bagging put on plank; reenforced wit loose earth.
3400-3405	583		1,900	Do.
3406-4619	606			Nothing required.
Total		115,248	109,050	

Levee work in Upper Tensas levee district in Arkansas and Louisiana, May 1, 1902, to May 1, 1903.

IN ARKANSAS.

[N.=New; E.=Enlargement.]

Stations.	Below Cairo.	Contractor.	In contract.	Placed during year.	Total laborers.	Total teams
	Miles.		*Cub. yds.*	*Cub. yds.*		
2087-2121	470 R	George R. Lacy	129,500	None.		
2121-2164	470 R	Donovan & Daley	128,800	None.		
2252-2533	486 R	Lewis & Jennings	144,000	107,694	6,396	4.6
3950-4080	515 R	M. L. Linnan	82,639	82,639	4,452	3,1
4080-4210	516 R	Donovan & Daley	100,000	79,230	4,396	3.0

IN LOUISIANA.

0-120	517 R	Dulaney, Sessions & Leonard	111,000	None.		
120-190	517 R	Donovan & Daley	111,000	None.		
190-256	523 R	M. L. Linnan	72,000	None.		

IN ARKANSAS.

Stations.	Below Cairo.	Total. scrapers.	Per team.	Per scrapers.	Price per cubic yard.	Average height.	Average haul.	Kind of work.
	Miles.		*Yards.*	*Yards.*	*Cents.*	*Feet.*	*Feet.*	
2087-2121	470 R				15.7			N.
2121-2164	470 R				16.0			N.
2252-2533	486 R	2,946	23	37	21.5	13.6	150	E.
3950-4080	515 R	2,045	27	40	16.0	14.8	225	E.
4080-4210	516 R	1,871	26	42	19.7	15.1	225	E.

Levee work in Upper Tensas levee district in Arkansas and Louisiana, May 1, 1902, to May 1, 1903—Continued.

IN LOUISIANA.

Stations.	Below Cairo.	Total scrapers.	Per team.	Per scrapers.	Price per cubic yard.	Average height.	Average haul.	Kind of work.
	Miles.		*Yards.*	*Yards.*	*Cents.*	*Feet.*	*Feet.*	
0–120	517 R				19.74			E.
120–190	517 R				17.25			E.
190–256	523 R				17.48	21.0		E.

Statement of work done in the Upper Tensas levee district in Arkansas and Louisiana by the Desha County, Chicot County, Tensas Basin, and Fifth Louisiana levee boards, and the State of Louisiana, from May 1, 1902, to May 1, 1903.

WORK DONE IN ARKANSAS.

	Cubic yards.	Cost.
Desha County levee board:		
Repair work		$199.50
High-water protection		2,191.00
Miscellaneous expenses		103.00
Tensas Basin levee board:		
Stations 1020–1240, Fulton Lake enlargement	20,000	6,900.00
High-water protection (labor)		3,368.50
High-water protection (material)		1,683.68
High-water protection (expended at Leland and Vaucluse)		1,000.00
Miscellaneous expense		2,947.32
Chicot County levee board:		
High-water protection (labor)		8,540.24
High-water protection (material)		4,729.72
Miscellaneous expense		1,946.87
Total	20,000	33,609.83

WORK DONE IN LOUISIANA.

Enlargement and new levee	433,587	$74,145.91
Weed cutting and repairs		864.97
High-water protection (labor)		14,680.05
High-water protection (material)		15,954.46
Miscellaneous expense		5,921.24
Total	433,587	111,566.63

RECAPITULATION.

Desha County levee board		$2,493.50
Tensas Basin levee board	20,000	15,899.50
Chicot County levee board		15,216.83
State and Fifth Louisiana levee board	433,587	111,566.63
Total	453,587	145,176.46

Work done above Redfork, Ark., by the Redfork levee board.

	Cubic yards.	Cost
Enlargement, Stations 121 to 644+27	351,997	$46,316.80
High-water protection (labor)		969.94
High-water protection (material)		759.62
Miscellaneous expense		3,938.82
Total	351,997	51,985.18

Comparison of high waters of 1897, 1898, and 1903.

IN ARKANSAS.

Station.	Below Cairo (R. B.)	Elevation, high water.		1903 above 1897.	Elevation, high water, 1898.	1903 above 1898.	Locality.
		1903.	1897.				
	Miles.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	
0	Ark. R.	172.82	170.99	1.83	168.97	3.85	Arkansas River.
232	Ark. R.	171.95	170.24	1.70			Do.
337	Ark. R.	171.79	170.12	1.70			Do.
0	427	162.88	162.88	0.00	161.65	1.23	Main Line.
495	428	159.71	159.01	0.70	157.87	1.82	Lucca Landing.
693	431	158.48	157.95	0.53	156.47	2.01	Chicot.
928	438	156.36	155.20	1.16	154.51	1.85	Arkansas City.
1511	450	152.51	151.76	0.75	150.94	1.57	Gaines Landing.
1941	467	148.23	147.03	1.20	146.20	2.03	Luna Landing.
2254	483	142.46	140.26	2.20	139.89	2.57	Leland.
2531	487	142.07	139.87	2.20	139.57	2.50	Vaucluse, Commission gauge No. 96.
2742	490	141.24	138.86	2.38	138.55	2.69	Sunnyside.
3040	495	139.48	136.93	2.55	136.64	2.84	Lakeport.
3382	504	136.12	133.57	2.55	133.26	2.86	Harwood.
3760	510	133.87	131.55	2.32	131.44	2.43	Grand Lake.
4049	516	131.07	128.85	2.22	128.75	2.32	Sterling.
4206	520	130.69	128.44	2.25	128.44	2.25	Louisiana State Line.

IN LOUISIANA.

Station.	Below Cairo (R. B.)	Elevation, high water, 1903.	Elevation, high water, 1897.	1903 above 1897.	Elevation, high water, 1898.	1903 above 1898.	Locality.
247	523	130.25	128.00	2.25	127.90	2.35	Pilchers Point.
947	532	126.20	123.80	2.40	123.90	2.30	Wilsons Point, Commission gauge No. 87.
1207	537	124.25	122.30	1.95	122.40	1.85	Benhams, Commission gauge No. 86.
1462	542	122.94	121.03	1.91	120.84	2.10	Lake Providence.
1815	547	122.30	120.05	2.25	120.05	2.25	Hollybrook.
1967	555	119.37	116.87	2.50	116.34	3.03	Point Lookout.
2354	561	117.17	115.67	1.50	114.99	2.18	Alsatia.
2670	565	116.02	114.22	1.80	113.16	2.86	Salem.
2815	574	112.05	110.90	1.15	109.48	2.57	Henderson.
3097	578	110.60	190.80	0.80	108.00	2.60	Omega, Commission gauge No. 79.
3602	587	108.19	108.09	0.10	105.55	2.64	Above Duckport.
3655	588	107.27	107.72	−0.45	104.90	2.37	Do.
3940	593	106.30	107.00	−0.70	103.80	2.50	Youngs Point, Commission gauge No. 76.
4222	600	105.10	105.80	−0.70	102.56	2.54	Delta.
4389	603	103.20	103.20	0.00	100.90	2.30	Commission gauge No. 75.
4606	606	101.70	103.00	−1.30			Bedford.

Cost of work done by the United States in the Lower Yazoo levee district from 1882 to May 1, 1903.

Stations.	Miles below Cairo.	Contractor.	Cubic yards.	Cost.
Levee construction 1882 to May 1, 1902			16,426,480	$2,469,655.38
Levee construction May 1, 1902, to May 1, 1903:				
3100-3125	434 L.	M. J. Roach & Co	82,416	14,612.36
3125-3156	434 L.	do	99,129	17,575.57
3156-3189	434 L.	do	142,165	a 28,006.51
3189-3229	434 L.	do	124,254	22,030.24
3229-3245+42a	434 L.	do	109,182	19,357.97
2572-2880	531 L.	Lowrance Bros	34,429	5,112.71
3800-3942	552 L.	L. C. Dulaney	24,334	4,351.65
4670-4725	567 L.	Israel R. Bobbitt	83,518	11,989.02
4725-4780	568 L.	do	123,518	18,564.76
4890-5000	569 L.	Donovan & Daley	18,644	3,255.24
Total levee construction May 1, 1902, to May 1, 1903			841,589	144,856.03
Total levee construction 1882 to May 1, 1903			17,268,069	2,614,511.41
High-water protection, repairs, and engineering expenses 1882 to May 1, 1902				445,090.91
High-water protection, repairs, and engineering expenses May 1, 1902, to May 1, 1903				22,067.67
Total high-water protection, repairs, and engineering expenses 1882 to May 1, 1903				467,158.58
Total cost to May 1, 1903				3,081,669.99

[a] Contract completed.

Cost of work done by the United States in the Upper Tensas levee district from 1882 to May 1, 1903.

Stations.	Miles below Cairo.	Contractor.	Cubic yards.	Cost.
Levee construction 1882 to May 1, 1902			21,525,812	$3,527,390.80
Levee construction May 1, 1902, to May 1, 1903, Arkansas:				
2252-2533	486 R.	Lewis & Jennings	102,652	19,863.16
3950-4080	515 R.	M. L. Linnan	82,639	[a] 13,222.24
4080-4210	516 R.	Donovan & Daley	74,480	13,205.31
Total levee construction May 1, 1902, to May 1, 1903			259,771	46,290.71
Total levee construction 1882 to May 1, 1903			21,785,583	3,573,681.51
High-water protection, repairs, and engineering expenses 1882 to May 1, 1902				747,207.62
High-water protection, repairs, and engineering expenses May 1, 1902, to May 1, 1903				20,968.88
Total high-water protection, repairs, and engineering expenses 1882 to May 1, 1903				768,176.50
Total cost to May 1, 1903				4,341,858.01

[a] Contract completed.

Financial statement.

ASHBROOK NECK.

Amount allotted during fiscal year by Mississippi River Commission from river and harbor act approved June 13, 1902	$35,000.00
June 30, 1903, amount expended during fiscal year	33,904.24
July 1, 1903, balance unexpended	1,095.76
July 1, 1903, outstanding liabilities	1,095.76
Amount that can be profitably expended in fiscal year ending June 30, 1905	60,000.00

GREENVILLE, MISS.

Amount allotted during fiscal year by Mississippi River Commission from river and harbor act approved June 13, 1902	25,000.00
June 30, 1903, amount expended during fiscal year	17,366.43
July 1, 1903, balance unexpended	7,633.57
July 1, 1903, outstanding liabilities	396.73
July 1, 1903, balance available	7,236.84
Amount that can be profitably expended in fiscal year ending June 30, 1905	50,000.00

LAKE PROVIDENCE REACH.

July 1, 1902, balance unexpended	9,500.57
June 30, 1903, amount expended during fiscal year	9,203.11
July 1, 1903, balance unexpended	297.46
July 1, 1903, outstanding liabilities	297.46
Amount that can be profitably expended in fiscal year ending June 30, 1905	25,000.00

PLANT, THIRD DISTRICT.

July 1, 1902, balance unexpended	$10,527.90
Amount allotted during fiscal year by Mississippi River Commission from river and harbor act approved June 13, 1902	65,000.00
	75,527.90
June 30, 1903, amount expended during fiscal year	36,413.38
	39,114.52
July 1, 1903, outstanding liabilities	8,000.00
July 1, 1903, balance available	31,114.52
July 1, 1903, amount covered by uncompleted contracts	25,000.00
Amount that can be profitably expended in fiscal year ending June 30, 1905	60,000.00

GENERAL REPAIRS TO EXISTING WORKS, THIRD DISTRICT.

Amount allotted during fiscal year by Mississippi River Commission from river and harbor act approved June 13, 1902		$50,000.00
June 30, 1903, amount expended during fiscal year account different works, as follows:		
Lake Bolivar front	$5,942.72	
Ashbrook Neck	13,309.81	
Greenville, Miss	3,437.50	
Lake Providence reach	18,250.32	
		40,940.35
July 1, 1903, balance unexpended		9,059.65
July 1, 1903, balance available		9,059.65
Amount that can be profitably expended in fiscal year ending June 30, 1905		50,000.00

STONE, THIRD DISTRICT.

July 1, 1902, balance unexpended	5,505.20
Amount allotted during fiscal year by Mississippi River Commission from river and harbor act approved June 13, 1902	50,000.00
	55,505.20
June 30, 1903, amount expended during fiscal year	24,586.46
July 1, 1903, balance unexpended	30,918.74
July 1, 1903, outstanding liabilities	100.00
July 1, 1903, balance available	30,818.74
Amount that can be profitably expended in fiscal year ending June 30, 1905	50,000.00

LOWER YAZOO LEVEE DISTRICT.

July 1, 1902, balance unexpended	13,229.33
Amount allotted during fiscal year by Mississippi River Commission from river and harbor act approved June 13, 1902	291,000.00
	304,229.33
June 30, 1903, amount expended during fiscal year	178,325.82
July 1, 1903, balance unexpended	125,903.51
July 1, 1903, outstanding liabilities	1,000.00
July 1, 1903, balance available	124,903.51
July 1, 1903, amount covered by uncompleted contracts	104,000.00
Amount that can be profitably expended during fiscal year ending June 30, 1905	500,000.00

UPPER TENSAS LEVEE DISTRICT.

ly 1, 1902, balance unexpended	$10,357.75
nount allotted during fiscal year by Mississippi River Commission from river and harbor act approved June 13, 1902	112,500.00
	122,857.75
ne 30, 1903, amount expended during fiscal year	71,845.13
ly 1, 1903, balance unexpended	51,012.62
ly 1, 1903, outstanding liabilities	800.00
ly 1, 1903, balance available	50,212.62
ly 1, 1903, amount covered by uncompleted contracts	30,000.00
nount that can be profitably expended during fiscal year ending June 30, 1905	500,000.00

SURVEYS, THIRD DISTRICT.

nount allotted during fiscal year by Mississippi River Commission from river and harbor act approved June 13, 1902	$5,000.00
ne 30, 1903, amount expended during fiscal year	4,326.17
ly 1, 1903, balance unexpended	673.83
ly 1, 1903, outstanding liabilities	200.00
ly 1, 1903, balance available	473.83
nount that can be profitably expended during fiscal year ending June 0, 1905	5,000.00

t of contracts in force June 30, 1903, in Third district, improving Mississippi River.

Contractor.	Kind of work.	Rate.	Date of approval.	Date of beginning work.	Expiration of contract.
J. Howard	Towboat and outfit.	$53,900	Mar. 18, 1903	June 8, 1903	Oct. 23, 1903
nter & Frey	Willow brush	[a]1.28	Emer. cont.	Sept. 1, 1902	[b]June 30, 1903
Do	Willow poles	[a]2.00			
Levee work in Lower Yazoo	*Levee District.*	*Per cubic yard, cents.*			
ove Greenville:	*Stations.*				
M. J. Roach & Co	1036-1080	13.89	May 25, 1903	Not begun.	Feb. 1, 1904
Do	1080-1116	13.89	May 25, 1903	Not begun.	Feb. 1, 1904
Do	1116-1150	13.89	May 25, 1903	Apr. 25, 1903	Feb. 1, 1904
Do	1150-1183	13.89	May 25, 1903	Apr. 9, 1903	Feb. 1, 1904
Do	1183-1226	13.89	May 25, 1903	May 1, 1903	Feb. 1, 1904
Lowrance Bros	1840-2070	18	May 23, 1903	Not begun.	Feb. 1, 1904
Do	2130-2230	17.9	May 25, 1903	Not begun.	Feb. 1, 1904
M. J. Roach & Co	3100-3125	19.7	Sept. 19, 1902	Sept. 19, 1902	[b]Feb. 1, 1903
Do	3125-3156	19.7	Sept. 19, 1902	Sept. 9, 1902	[b]Feb. 1, 1903
Do	3189-3229	19.7	Sept. 19, 1902	Sept. 10, 1902	[b]Feb. 1, 1903
Do	3229-3245+42a	19.7	Sept. 19, 1902	Oct. 1, 1902	[b]Feb. 1, 1903
ow Greenville:					
Walker Stansell	100- 200	15.74	June 19, 1903	Not begun.	Feb. 1, 1904
Do	600- 790	15.74	May 25, 1903	Feb. 23, 1903	Feb. 1, 1904
Do	1346-1730	15.74	May 25, 1903	May 26, 1903	Feb. 1, 1904
Do	1730-2103	15.74	May 25, 1903	Feb. 23, 1903	Feb. 1, 1904
Lowrance Bros	2572-2880	16.5	Nov. 11, 1902	Nov. 6, 1902	[b]Feb. 1, 1903
L. C. Dulaney	3800-3942	19.87	Emer. cont.	Oct. 21, 1902	[b]Apr. 1, 1903
I. R. Bobbitt	4670-4725	15.95	Oct. 20, 1902	Nov. 1, 1902	[b]Feb. 1, 1903
T. Worthington	4780-4890	19.4	Emer. cont.	Not begun.	[b]Apr. 1, 1903
Donovan & Daley	4890-5000	19.4	Emer. cont.	Nov. 10, 1902	[b]Apr. 1, 1903
Morgan & McCarten	5000-5170	19.875	Emer. cont.	Not begun.	[b]Apr. 1, 1903
ee work in Upper Tensas	*Levee District.*				
ansas:					
Geo. R. Lacy	2087-2121	15.7	May 23, 1903	Not begun.	Feb. 1, 1904
Donovan & Daley	2121-2164	16	May 25, 1903	May 2, 1903	Feb. 1, 1904
Lewis & Jennings	2252-2533	21.5	Sept. 22, 1902	Sept. 17, 1902	[b]Feb. 1, 1903
Donovan & Daley	4080-4210	19.7	Oct. 11, 1902	Sept. 26, 1902	[b]Feb. 1, 1903
isiana:					
Dulaney, Sessions & Leonard.	0- 120	19.74	May 25, 1903	May 20, 1903	Feb. 1, 1904
Donovan & Daley	120- 190	17.25	May 25, 1903	Not begun.	Feb. 1, 1904
M. L. Linnan	190- 256	17.48	Nov. 11, 1902	Not begun.	[b]Feb. 1, 1903

[a] Per cord.

[b] Time limit waived.

APPENDIX 4.

REPORT OF CAPT. CHARLES S. BROMWELL, CORPS OF ENGINEERS, ON OPERATIONS IN THE FOURTH DISTRICT.

UNITED STATES ENGINEER OFFICE,
New Orleans, La., June 1, 1903.

COLONEL: I have the honor to submit the following report upon the work of the Fourth district, Mississippi River improvement, for the period from June 1, 1902, to June 1, 1903:

The Fourth district extends from Warrenton, 7½ miles below Vicksburg, to the Head of the Passes, about 13 miles from the Gulf of Mexico, a distance of 452.8 miles by river.

The works include the improvement of the harbors at Natchez and Vidalia, Miss. and La.; improvements at the junction of the Mississippi, Red, and Atchafalaya rivers; improvement of the harbor of New Orleans, La.; bank protection in Bondurant Chute; bank protection in Kempe Bend, and the construction, repair, and maintenance of the levee system of the district.

This work was in charge of Maj. George McC. Derby, Corps of Engineers, until September 30, 1902, and since that date in charge of Capt. Charles S. Bromwell, Corps of Engineers.

HARBORS OF NATCHEZ AND VIDALIA.

The project for this work, adopted June 29, 1891, contemplates the construction of a levee on or near the axis of Cowpen Neck, to prevent the flow of water across the neck during high stages of the river, and the construction of about 16,000 linear feet of bank revetment in Giles Bend. Estimated cost, $541,300.

The object of the proposed work is to prevent the formation of a threatened cut-off at Cowpen Neck, which would cause the destruction of the town of Vidalia, much injury to the water front at Natchez, and the probable destruction of parts of the levee system, due to increased caving of the banks above and below.

At the beginning of the fiscal year there was in place about 11,130 linear feet of revetment of various kinds measured parallel to the general shore line, and the work was generally in good condition.

The work proposed for the past season was as follows: To prolong the lower Giles Bend revetment upstream about 1,000 feet; to mattress the intervals between spurs 1 and 2 and 2 and 3 upper Giles Bend revetment, and to maintain their connection with the shore and to make such minor repairs to existing revetment as might be found necessary.

Work was begun at this locality July 29, 1902, and was carried on in connection with other works in the locality until December 13, 1902, when operations were suspended.

All of the work included in the above project was completed as well as 1,200 additional linear feet of revetment not so included. As a result of this season's work the continuous revetment at the lower end of the bend was prolonged upstream a distance of 1,400 feet, making its total length 6,880 feet, measured parallel to the general shore line; the gap in this revetment, 115 feet in length, and purposely left to allow a salient point to wear back to the general line of the revetment, was left unchanged, and two mats 300 feet wide were sunk in the bight of a large pocket above the revetment to check its further recession.

In the upper bend two mattresses 300 feet wide were sunk below spur 15, the intervals between spurs 1, 2, and 3 were mattressed, and the shore connections were repaired, making the revetment continuous and about 7,300 feet in length measured parallel to the general shore line.

During the year 836,575 square feet of mats were constructed and towed from the willow bars above and placed in the revetment at a cost of $0.062 per square foot; 89,752 square feet of concrete upper-bank pavement were laid at a cost of $0.049 per square foot, and 3,050 linear feet of revetment measured parallel to the general shore line was constructed at a gross cost of $22.86 per linear foot of bank, measured along the actual shore line.

During the past high water some protection work was necessary to maintain the levee on Cowpen Neck in good condition.

A survey of Giles Bend completed in December, 1902, shows that the existing work is in good condition, and as far as is known at this time it is thought that the works have not been seriously damaged by the past high water.

During the high water some caving occurred in the bank in the harbor at Natchez. It is impossible at this stage of the river to determine the extent of the damage, but as soon as practicable an examination of the locality will be made.

At the end of the completed revetment there is always more or less caving, and it will be necessary next season to prolong the revetment to prevent the caving flanking the completed revetment.

The details of this work and its cost are set forth in the appended report of my assistant, Mr. H. S. Douglas. Sketches are herewith showing the location of the work done and the rate of caving of the bank.

The amount expended from June 30, 1902, to June 30, 1903, is $60,000, distributed as follows:

Office expenses, main office		$2,406.62
Other administrative expenses		1,197.07
Construction of revetment (hired labor):		
Materials	$8,231.69	
Wages	23,018.51	
Subsistence	8,352.88	
		39,603.08
Manufacture of concrete ballast		11,145.54
Surveys		574.43
Repairs to plant		1,509.45
Care of plant		1,433.31
New plant		1,221.72
Protection of Cowpen Neck levee		908.78
Total		60,000.00

Money statement.

IMPROVING MISSISSIPPI RIVER—ALLOTMENT FOR HARBORS AT NATCHEZ AND VIDALIA, MISSISSIPPI AND LOUISIANA.

June 26, 1902, amount allotted, act of June 13, 1902		$60,000.00
July 1, 1902, amount available for expenditure		60,000.00
June 30, 1903, amount expended during fiscal year		60,000.00
Amount that can be profitably expended in fiscal year ending June 30, 1905:		
For works of improvement	$150,000.00	
For maintenance of improvement	10,000.00	
		160,000.00

Submitted in compliance with requirements of sundry civil act of June 4, 1897, and of section 7 of river and harbor act of 1899.

IMPROVING ATCHAFALAYA AND RED RIVERS, LOUISIANA.

The present project, adopted October 3, 1890, is to secure and maintain navigable connections at all stages of the water between the Red and Mississippi rivers and between the Mississippi and Atchafalaya rivers; to prevent the enlargement of the Atchafalaya River, and to secure and maintain, by dredging through lower Old River, a navigable channel between the Mississippi and Atchafalaya rivers, 75 feet wide at the bottom and having a depth of 5 feet below the zero of the Barbres gauge.

On account of lack of funds the first feature of the approved project has been definitely abandoned, narrowing the project to preventing the enlargement of the Atchafalaya River and maintaining a navigable channel through lower Old River.

Work was commenced January 22, 1903, and completed in this locality February 11, 1903.

Under this project Sill Dam No. 3 was widened to 560 feet by an apron mattress placed on the upstream side of the dam. This mattress contained 120,000 square feet, and was sunk at a cost of $0.062 per square foot.

A survey of the Atchafalaya River between Dams Nos. 1 and 3 was made, and a sketch is herewith, showing the location of the mats and the hydrography of the river.

The details of the work and its cost are set forth in the accompanying report of my assistant, Mr. H. S. Douglas.

At the present stage of the river nothing is known of the condition of the work, but it is believed to be good.

No further construction work is believed to be necessary at this locality during the ensuing year.

During the past year no dredging was required in lower Old River. The dredge *Ram* was kept in repair for this work if it should become necessary.

The amount expended from June 30, 1902, to June 30, 1903, is $10,529.56, distributed as follows:

Office expenses, main office		$518.54
Other administrative expenses		134.75
Repairs to sill dams (hired labor):		
Materials	$2,102.02	
Wages	3,094.45	
Subsistence	2,200.83	
		7,397.30
Manufacture of concrete ballast		929.33
Surveys		672.28
Repairs to plant		80.00
Care of plant		124.27
New plant		117.30
Miscellaneous		65.00
Dredging Old River:		
Repairs to plant	$453.25	
New plant	21.17	
Administrative expenses	16.37	
		490.79
Total		10,529.56

Money statement.

IMPROVING MISSISSIPPI RIVER—ALLOTMENT FOR ATCHAFALAYA AND RED RIVERS, LOUISIANA.

June 26, 1902, amount allotted, act of June 13, 1902	$15,000.00
July 1, 1902, amount available for expenditure	15,000.00
June 30, 1903, amount expended during fiscal year	10,529.56
July 1, 1903, balance unexpended	4,470.44
July 1, 1903, balance available	4,470.44
Amount that can be profitably expended in fiscal year ending June 30, 1905, in addition to the balance unexpended July 1, 1903, for maintenance of improvement	10,000.00
Submitted in compliance with requirements of sundry civil act of June 4, 1897, and of section 7 of river and harbor act of 1899.	

NEW ORLEANS HARBOR.

The project for this locality contemplates the protection of all caving banks in the harbor. Where the slope of the subaqueous bank is moderate, the protection is afforded by spur dikes placed at suitable intervals; where the slope of the subaqueous bank is excessive, the protection is afforded by continuous revetment placed outside of the 60-foot contour, the steep bank inside of that limit being cut down, either by natural or by artificial means, until the slope becomes moderate, when the continuous revetment will be laid inside of the 60-foot contour.

The work proposed for the season was extending the continuous revetment 1,800 feet above Southport, completing last year's project, and extending it downstream 4,750 feet below Southport.

Mattress construction for work in New Orleans Harbor was begun at Kempe Towhead in October, 1902, but owing to an unexpected and necessary change of plans these mattresses were sunk at Giles Bend to save them from loss.

Work was resumed January 22, 1903, and was suspended March 16 on account of the high stage of the river. The work of sinking was carried on with great difficulty and expense, as the mats were sunk when the river was within 2 feet of the highest recorded stage. One hundred and fifty-seven thousand five hundred square feet of mats were sunk at a cost of $0.142 per square foot.

Seven hundred and fifteen linear feet of mattress were sunk upstream at a point 840 feet above the wharf at Southport, at a gross cost of $31.42 per linear foot.

Surveys at Southport, Gouldsboro, and a partial survey at Algiers Point, made in January and February, show that existing works were in good condition, and as far as is known at this time it is thought that the works have not been seriously damaged by the past high water.

Work will be continued next season and last year's project will be completed. Further surveys will be made below Southport to determine the point to which the continuous revetment should be eventually extended,

For the conditions in New Orleans Harbor I have to invite attention to Major Derby's report for last year, in whose conclusions I entirely concur. More liberal appropriations should be made for this locality, as has been repeatedly recommended.

The details of the work and its cost are set forth in the appended report of my assistant, Mr. H. S. Douglas, assistant engineer. Sketches are also herewith, showing the location of the work done and the rate of caving of the bank.

The amount expended from June 30, 1902, to June 30, 1903, derived in part from the appropriation for improving harbor at New Orleans, La., and in part from an allotment made by the Mississippi River Commission for improving Mississippi River, allotment for New Orleans Harbor, Louisiana, is distributed as follows:

Office expenses, main office		$2,439.34
Other administrative expenses		1,680.71
Construction of revetment (hired labor):		
Materials	$17,633.98	
Wages	11,667.62	
Subsistence	3,775.72	
		33,077.32
Surveys		492.30
Repairs to plant		1,149.11
Care of plant		1,489.16
New plant		2,278.32
Total		42,606.26

Money statement.

IMPROVING HARBOR AT NEW ORLEANS, LA.

July 1, 1902, Balance unexpended	$20,218.67
June 30, 1903, amount expended during fiscal year	20,218.67
Amount that can be profitably expended during fiscal year ending June 30, 1905	300,000.00

Submitted in compliance with requirements of sundry civil act of June 4, 1897.

Money statement.

IMPROVING MISSISSIPPI RIVER, ALLOTMENT FOR NEW ORLEANS HARBOR, LOUISIANA.

June 26, 1902, amount allotted, act of June 13, 1902	$95,000.00
July 1, 1902, amount available for expenditure	95,000.00
June 30, 1903, amount expended during fiscal year	22,387.59
July 1, 1903, balance unexpended	72,612.41
July 1, 1903, outstanding liabilities	5.88
July 1, 1903, balance available	72,606.53

BONDURANT CHUTE REVETMENT.

The project for this work, adopted June 20, 1899, contemplates the construction of a continuous revetment of the bank for a distance of 1,600 feet for the protection of the levee line in that vicinity.

At the beginning of the fiscal year 1,600 linear feet of revetment were in place and was generally in good condition.

The work proposed for the past season was to extend this revetment 600 feet farther downstream and to repair the upper bank pavement where necessary.

Work was begun at this locality July 10, 1902, and was carried on in connection with other works in the locality until November 21, 1902, when the project was completed.

During the year 75,150 square feet of mats were constructed and towed from the willow bars above and placed in the revetment at a cost of $0.0645 per square foot; 27,245 square feet of concrete upper bank pavement were laid at a cost of $0.065 per square foot; and 600 linear feet of revetment was constructed at a gross cost of $16.93 per linear foot.

No survey of the locality was made during the past year; but, as far as is known at this time, it is thought that the works have not been seriously damaged by the past high water.

It is not believed that any work will be necessary at this locality next year beyond the current repairs.

The details of this work and its cost are set forth in the appended report of my assistant, Mr. H. S. Douglas. Sketches are also herewith showing the location of the work done and the rate of caving of the bank.

The amount expended from June 30, 1902, to June 30, 1903, is $10,000, distributed as follows:

Office expenses, main office		$887.44
Other administrative expenses		402.72
Construction of revetment (hired labor):		
Materials	$175.67	
Wages	3,964.92	
Subsistence	2,167.38	
		6,307.97
Manufacture of concrete ballast		1,146.00
Surveys		21.32
Repairs to plant		415.96
Care of plant		330.46
New plant		488.13
Total		10,000.00

Money statement.

BONDURANT CHUTE.

June 26, 1902, amount allotted, act of June 13, 1902		$10,000.00
July 1, 1902, amount available for expenditure		10,000.00
June 30, 1903, amount expended during fiscal year		10,000.00
Amount that can be profitably expended in fiscal year ending June 30, 1905:		
For works of improvement	$3,000.00	
For maintenance of improvement	2,000.00	
		5,000.00
Submitted in compliance with requirements of sundry civil act of June 4, 1897, and of section 7 of river and harbor act of 1899.		

KEMPE BEND REVETMENT.

The project for this work, approved May 1, 1899, contemplates the construction of a continuous revetment of the bank for such a distance as may be necessary for the protection of the levee line in that vicinity.

At the beginning of the fiscal year there was in place about 4,030 linear feet of revetment measured parallel to the general shore line, and the work was generally in good condition.

The work proposed for the past season was as follows: To extend the revetment about 600 feet downstream, to extend it about 900 feet upstream, to revet about 900 feet of bank in front of the salient of the levee, about 4,800 feet above the then upper end of the revetment, and to make such repairs to the existing revetment as might be necessary.

Work was begun at this locality August 15, 1902, and was carried on in connection with other works in the vicinity until December 27, 1902, when the project was completed.

As a result of this season's work the continuous revetment was extended 1,450 feet, making its total length 5,480 feet, measured parallel to the general shore line, and 850 feet of revetment was placed in front of the salient before mentioned. During the year 762,105 square feet of mats were constructed and towed from the willow bars above and placed in the revetment at a cost of $0.065 per square foot, 70,637 square feet of concrete upper bank pavement were laid at a cost of $0.060 per square foot, and 2,300 linear feet of revetment, measured parallel to the general shore line, was constructed at a gross cost of $30.87 per linear foot of bank, measured along the actual shore line.

A survey of Kempe Bend, completed in October, 1902, shows that the existing work is in good condition and, as far as is known at this time, it is thought that the works have not been seriously damaged by the past high water.

It will probably be necessary next year to prolong the revetment downstream and to eventually close the gap in the two portions of the revetment.

The details of this work and its cost are set forth in the appended report of my assistant, Mr. H. S. Douglas. Sketches are also herewith showing the location of the work done and the rate of caving of the bank.

The amount expended from June 30, 1902, to June 30, 1903, is $82,045.74, distributed as follows:

Office expenses, main office		$2,807.47
Other administrative expenses		3,253.37
Construction of revetment (hired labor):		
Materials	$11,440.36	
Wages	31,995.96	
Subsistence	15,951.76	
		59,388.08
Manufacture of concrete ballast		11,666.25
Surveys		534.67
Repairs to plant		933.93
Care of plant		2,292.40
New plant		1,098.89
Miscellaneous		70.68
Total		82,045.74

Money statement.

KEMPE BEND REVETMENT.

July 1, 1902, balance unexpended		$22,045.74
June 26, 1902, amount allotted, act of June 13, 1902		60,000.00
July 1, 1902, amount available for expenditure		82,045.74
June 30, 1903, amount expended during fiscal year		82,045.74
Amount that can be profitably expended during fiscal year ending June 30, 1905:		
For works of improvement	$75,000.00	
For maintenance of improvement	10,000.00	
		85,000.00
Submitted in compliance with the requirement of sundry civil act of June 4, 1897, and of section 7 of river and harbor act of 1899.		

PLANT.

The plant of the district now consists of 49 large pieces and has a capacity of about 7,500 linear feet of bank revetment. During the year two steel hull tugboats were purchased; ten barges are being constructed under contract and proposals for four more will be opened June 11, 1903.

During the year the necessary repairs to the plant have been made, and it is in generally good condition. A detailed statement of the work done for care and maintenance of the plant is given in the appended report of my assistant, Mr. H. S. Douglas.

The amount expended from June 30, 1902, to June 30, 1903, is $66,170.31, distributed as follows:

Office expenses, main office		$46.25
Other administrative expenses		2,589.80
New plant		45,498.97
Repairs (hired labor):		
Materials	$5,189.05	
Wages	8,761.57	
Subsistence	834.85	
		14,785.47
Care of plant		3,244.82
Miscellaneous		5.00
Total		66,170.31

Money statement.

PLANT.

June 26, 1902, amount allotted, act of June 13, 1902	$111,000.00
September 19, 23, 1902, amount received from proceeds of sales of engineer property at auction	540.81
Amount available for expenditure	111,540.81
June 30, 1903, amount expended during fiscal year	66,170.31
July 1, 1903, balance unexpended	45,370.50
July 1, 1903, outstanding liabilities	2,687.93
July 1, 1903, balance available	42,682.57
July 1, 1903, amount covered by uncompleted contracts	40,000.00

SURVEYS, GAUGES, AND OBSERVATIONS.

During the year surveys were made at Kempe Bend, Giles Bend, Atchafalaya Sill Dams, Southport, Gouldsboro Bend, and at Algiers Point, and the bank lines have been surveyed in caving bends at the following localities:

Point Pleasant to Buckridge (622 R.), Hard Times Bend (626–633 R.), Waterproof to L'Argent (678–679 R.), Forrest to Warricut (710 R.), and from Greens to Fairview (720–728 R.).

The gauge at Barbres Landing at the junction of the Red and Atchafalaya rivers has been maintained as heretofore.

The amount expended from June 30, 1902, to June 30, 1903, is $5,000, distributed as follows:

Administrative expenses		$101.52
Field work and drafting:		
Materials	$234.26	
Wages	3,073.78	
Subsistence	991.21	
		4,299.25
Repairs to plant		232.05
Care of plant		43.57
New plant		200.26
Miscellaneous		23.35
Maintenance of gauge at Barbres, La		100.00
Total		5,000.00

Money statement.

SURVEYS, GAUGES, AND OBSERVATIONS.

June 26, 1902, amount allotted, act of June 13, 1902	$5,000.00
July 1, 1902, amount available for expenditures	5,000.00
June 30, 1903, amount expended during fiscal year	5,000.00

LEVEES.

For work connected with levee construction and maintenance the district is subdivided into seven levee districts, as follows:

The Lower Tensas levee district, right bank, which extends from the upper limits of the Fourth district, opposite Warrenton, to the mouth of Red River. In this district the levee system is continuous from the upper end to a point about 9 miles below Fairview Landing, 135.28 miles by river, leaving about 22 miles unprotected.

The Atchafalaya levee district, right bank, which extends from the mouth of Red River to the head of Bayou Lafourche, a distance of 122 miles by river. The levee system is continuous in this district.

The Lafourche levee district, right bank, which extends from the head of Bayou Lafourche to New Orleans. The distance by river is 78 miles and the levee system is continuous.

The Barataria levee district, right bank, which extends from New Orleans to the Head of the Passes, 82½ miles. The levee system is continuous down to the Jump, 71.5 miles.

The Homochitto levee district, left bank, created by a resolution of the Missisippi River Commission November 19, 1894, which extends from the mouth of he Yazoo River to Baton Rouge, 238.5 miles by river. There are as yet no levees n this district except a few detached lengths built by private parties.

The Pontchartrain levee district, left bank, which extends from Baton Rouge o New Orleans, 123.5 miles. The levee system is continuous.

The Lake Borgne levee district, left bank, which extends from New Orleans to the Head of the Passes, 91 miles. The levee system at present only extends to Fort St. Philip, covering 70 miles of the river.

The funds available for levee construction in this district amounted to $314,815.02, being the unexpended balances from previous allotments and $271,500 allotted for this purpose June 13, 1902.

The levee line has been improved this year by the United States to the extent of 1,317,000 cubic yards, at an average cost of 14.40 cents per cubic yard. The following table shows the variation in cost of levee building by the United States in recent years:

Year.	Cubic yardage.	Cost per cubic yard.	Year.	Cubic yardage.	Cost per cubic yard.
		Cents.			*Cents.*
1890	895,000	19.3	1897	1,775,000	10.99
1891	1,410,000	21.2	1898	3,392,000	14.12
1892	908,000	17.8	1899	2,465,000	13.6
1893	2,142,000	21.2	1900	2,735,000	13.23
1894	3,589,000	15.0	1901	332,000	14.26
1895	3,414,000	12.3	1902	1,316,918	14.40
1896	4,658,000	10.3			

The following table shows approximately the present condition of the levee ines:

	Levee districts.					
	Lower Tensas.	Atchafalaya.	Lafourche.	Pontchartrain.	Barataria.	Lake Borgne.
Above high water of 1897:	*Miles.*	*Miles.*	*Miles.*	*Miles.*	*Miles.*	*Miles.*
Less than 1 foot	2.36		0.70	21.00	2.14	
From 1 to 2 feet	3.01		12.29	27.89	27.81	34.14
From 2 to 3 feet	23.23	11.44	22.80	22.82	23.92	14.18
More than 3 feet	106.68	116.33	46.13	53.86	17.79	23.03
Total	135.28	127.77	81.92	125.57	71.66	71.35

No work has been done in the Homochitto levee district, there having been no unds available.

On March 11 the gauge at Cairo read 48.9 feet, and as the flooded condition of he Ohio and its tributaries indicated a still further rise in the river, preparations vere made for the maintenance of the levee line during the high water.

As the funds on hand for the purpose were limited, it was decided to work in cooperation with the local levee boards, the United States furnishing boats and barges and a limited amount of lumber and tools, while the levee boards furnished the labor and additional lumber and tools.

The tools and barges were placed at convenient points along the river in charge of a competent employee of this office.

These barges were moved immediately under the direction of the office, but in case of emergency the members of the local levee boards were authorized to move them as occasion demanded, reporting their action to this office.

It was intended that all small repairs to the levees should be made with the materials and tools on the barges, and that in case of serious repairs, or of a crevasse, the tools and materials would be sufficient to start work immediately and to enable it to be carried on until the levee board could get additional material to the spot and organize the forces.

The entire line of levees was subdivided into sections in charge of an employee of this office, who had assistants under him who carefully patrolled the levees. This system of protection was maintained until April 28, when, the danger having passed, all the employees, boats, etc., were withdrawn.

In several of the districts it was necessary to raise certain portions of the levees where they were below the grade of probable high water or but slightly above it. The following lengths of levee were raised by the United States or by the local levee boards:

Lower Tensas levee district	feet	8,700
Pontchartrain levee district	miles	21.62
Lafourche levee district	feet	4,400
Barataria levee district	miles	4.25
Lake Borgne levee district	do	11.33

The cheapest and most satisfactory method was by using a plank revetment with earth backing. Capping of the kind done by the United States cost 40 cents per cubic yard.

The usual measures were taken, with good success, to prevent or repair damage due to wave wash, leaks, sloughing, sand boils, etc.

Crevasses occurred at Bougere (738 R.), Hymelia (928 R.), Magnolia (1011 L.), Pinauds (1018 R.), Simmes (1019 R.), six between Grandison (1023 R.) and Vogt (1025 R.), and two between Cuselich Canal and Polites Canal (1036 R.). With the exception of those at Bougere and Hymelia, the crevasses were unimportant and did but little damage. Efforts were made by the local authorities to close the Hymelia crevasse, but without success. One thousand three hundred and twenty square miles of country were inundated as a result of the Hymelia crevasse, of which 20 square miles were under cultivation.

The river in this district, from St. Joseph down, was higher than the 1897 water by from two-tenths of a foot to one and four-tenths feet.

The cost of the high water protection work was about $34,353, and the details of the work accomplished in the various levee districts are given in the following tables and are further discussed in the accompanying report of Mr. W. E. Knobloch, superintendent of levees.

Fourth district levees, 1902-3.

LOWER TENSAS LEVEE DISTRICT.

No.	Name of levee.	Miles below Cairo.	Bank.	Contractor.	Length of line.	Length of axis of river covered.	Grade of levee above highest known water.
	Canebrake:				*Feet.*	*Feet.*	
1	Section 1	683	R.	Helgason Bros	835	770	5
2	Section 2	683	R.	do	900	860	5
3	Section 3	683	R.	do	600	570	5
4	Section 4	683	R.	do	600	580	5
5	Section 5	683	R.	do	700	650	5
6	Section 6	683	R.	do	500	480	5
	Shamrock:						
7	Section 1	684	R.	do	500	480	5
8	Section 2	684	R.	do	500	470	5
9	Section 3	684	R.	do	700	640	5
10	Section 4	684	R.	do	700	650	5
11	Section 5	684	R.	do	700	640	5
12	Section 6	684	R.	do	1,000	1,180	5

Fourth district levees, 1902-3—Continued.

LOWER TENSAS LEVEE DISTRICT—Continued.

No.	Name of levee.	Miles below Cairo.	Bank.	Contractor.	Length of line.	Length of axis of river covered.	Grade of levee above highest known water.
	Vaucluse:				*Feet.*	*Feet.*	*Feet.*
13	Section 1	685	R.	James R. Marlow	1,000	1,600	5
14	Section 2	685	R.	do	900	1,450	5
15	Section 3	685	R.	do	900	1,450	5
16	Section 4	685	R.	do	1,100	1,790	5
17	Section 5	685	R.	do	900	1,450	5
18	Section 6	685	R.	do	919	1,500	5
	Roseland:						
19	Section 1	720	R.	R. T. Clark	1,456	1,875	5
20	Section 2	720	R.	do	1,300	1,740	5
21	Section 3	720	R.	do	1,800	1,740	5
22	Section 4	720	R.	do	1,400	1,860	5
23	Section 7	731	R.	do	1,700	2,400	5
	Excelsior:						
24	Section 1	732	R.	do	1,600	1,720	5
25	Section 2	732	R.	do	1,400	1,500	5
26	Section 3	732	R.	do	1,500	1,600	5
27	Section 4	733	R.	do	1,600	1,720	5
28	Section 5	733	R.	do	1,100	1,175	5
29	Section 6	733	R.	do	1,200	1,850	5
30	Section 7	733	R.	do	1,440	1,520	5
	Wildwood:						
31	Section 4	735	R.	C. H. Whipple	1,800	1,740	5
32	Section 5	735	R.	do	1,300	1,740	5
	Home Place:						
33	Section 1	736	R.	R. T. Clark	1,200	1,420	5
34	Section 2	736	R.	do	700	830	5
35	Section 3	736	R.	do	1,000	1,180	5
36	Section 4	736	R.	do	800	910	5
37	Section 6	737	R.	do	1,268	1,590	5
	Ashland:						
38	Section 1	738	R.	do	979	820	5
39	Section 2	738	R.	do	1,100	980	5
40	Section 3	238	R.	do	1,100	930	5
41	Section 4	738	R.	do	1,800	1,100	5
42	Section 5	738	R.	do	1,000	840	5

No.	Name of levee.	Section. Crown.	Section. Land slope.	Section. River slope.	New or enlargement.	Average height—Above old levee.	Average height—Above ground surface.	Date of contract.	Work completed.
	Canebrake:	*Ft.*				*Feet.*	*Feet.*		
1	Section 1	8	3 to 1	3 to 1	Enlargement.	3.8	15.4	Sept. 9, 1902	Nov. 10, 1902
2	Section 2	8	3 to 1	3 to 1	do	3.8	17.0	do	Dec. 10, 1902
3	Section 3	8	3 to 1	3 to 1	do	3.8	18.2	do	Jan. 20, 1903
4	Section 4	8	3 to 1	3 to 1	do	3.8	17.7	do	Mar. 2, 1903
5	Section 5	8	3 to 1	3 to 1	do	3.8	18.5	do	Do.
6	Section 6	8	3 to 1	3 to 1	do	3.8	23.2	do	Nov. 22, 1902
	Shamrock:								
7	Section 1	8	3 to 1	3 to 1	do	3.4	28.2	do	Nov. 10, 1902
8	Section 2	8	3 to 1	3 to 1	do	3.4	26.9	do	Nov. 12, 1902
9	Section 3	8	3 to 1	3 to 1	do	3.4	20.1	do	Dec. 9, 1902
10	Section 4	8	3 to 1	3 to 1	do	3.4	18.6	do	Dec. 24, 1902
11	Section 5	8	3 to 1	3 to 1	do	3.4	18.4	do	Mar. 4, 1903
12	Section 6	8	3 to 1	3 to 1	do	3.4	17.3	do	Jan. 20, 1903
	Vaucluse:								
13	Section 1	8	3 to 1	3 to 1	do	3.3	15.2	July 28, 1902	Jan. 19, 1903
14	Section 2	8	3 to 1	3 to 1	do	3.3	16.3	do	Do.
15	Section 3	8	3 to 1	3 to 1	do	3.3	16.3	do	Dec. 10, 1902
16	Section 4	8	3 to 1	3 to 1	do	3.3	14.4	do	Nov. 27, 1902
17	Section 5	8	3 to 1	3 to 1	do	3.3	14.9	do	Oct. 30, 1902
18	Section 6	8	3 to 1	3 to 1	do	3.3	12.9	do	Oct. 2, 1902
	Roseland:								
19	Section 1	8	3 to 1	3 to 1	do	4.3	10.5	do	Mar. 7, 1903
20	Section 2	8	3 to 1	3 to 1	do	6.6	9.4	do	Mar. 4, 1903
21	Section 3	8	3 to 1	3 to 1	do	5.8	9.6	do	Jan. 17, 1903
22	Section 4	8	3 to 1	3 to 1	do	5.1	9.6	do	Feb. 10, 1903
23	Section 7	8	3 to 1	3 to 1	do	4.6	10.6	do	Do.

Fourth district levees, 1902-3—Continued.

LOWER TENSAS LEVEE DISTRICT—Continued.

No.	Name of levee.	Section.				Average height—		Date of contract.	Work completed.
		Crown.	Land slope.	River slope.	New or enlargement.	Above old levee.	Above ground surface.		
	Excelsior:	*Ft.*				*Feet.*	*Feet.*		
24	Section 1	8	3 to 1	3 to 1	Enlargement.	4.7	9.8	July 28, 1902	Dec. 21, 1902
25	Section 2	8	3 to 1	3 to 1	do	4.0	11.0	do	Oct. 29, 1902
26	Section 3	8	3 to 1	3 to 1	do	4.5	9.5	do	Jan. 17, 1903
27	Section 4	8	3 to 1	3 to 1	do	4.6	8.6	do	Mar. 4, 1903
28	Section 5	8	3 to 1	3 to 1	do	4.9	10.0	do	Mar. 12, 1903
29	Section 6	8	3 to 1	3 to 1	do	6.0	9.1	do	Dec. 21, 1902
30	Section 7	8	3 to 1	3 to 1	do	6.3	9.3	do	Nov. 1, 1902
	Wildwood:								
31	Section 4	8	3 to 1	3 to 1	do	6.7	9.4	Nov. 10, 1902	Apr. 25, 1903
32	Section 5	8	3 to 1	3 to 1	do	6.8	8.4	do	Do.
	Home Place:								
33	Section 1	8	3 to 1	3 to 1	do	6.6	9.3	July 28, 1902	Dec. 21, 1902
34	Section 2	8	3 to 1	3 to 1	do	10.2	10.8	do	Nov. 30, 1902
35	Section 4	8	3 to 1	3 to 1	do	6.7	10.2	do	Oct. 24, 1902
36	Section 4	8	3 to 1	3 to 1	do	7.9	13.3	do	Feb. 12, 1903
37	Section 6	8	3 to 1	3 to 1	do	6.5	10.9	do	Mar. 14, 1903
	Ashland:								
38	Section 1	8	3 to 1	3 to 1	New		8.3	do	Oct. 29, 1902
39	Section 2	8	3 to 1	3 to 1	do		8.3	do	Nov. 27, 1902
40	Section 3	8	3 to 1	3 to 1	do		8.3	do	Dec. 2, 1902
41	Section 4	8	3 to 1	3 to 1	do		8.6	do	Dec. 19, 1902
42	Section 5	8	3 to 1	3 to 1	do		9.0	do	Oct. 23, 1902

No.	Name of levee.	Total yardage paid for.	Price per cubic yard.	Total cost.	Distance from center of levee to river bank.			Nature of bank.
					Least.	Greatest.	Average.	
	Canebrake:		*Cents.*		*Feet.*	*Feet.*	*Feet.*	
1	Section 1	12,104.69	21.00	$2,541.99	1,400	1,900	1,600	Caving.
2	Section 2	13,465.57	21.00	2,827.77	1,850	1,950	1,900	Do.
3	Section 3	10,467.02	21.00	2,198.07	1,950	2,100	2,000	Do.
4	Section 4	10,831.99	21.00	2,274.72	2,100	2,300	2,220	Do.
5	Section 5	11,841.24	21.00	2,486.66	2,300	2,550	2,450	Do.
6	Section 6	11,263.75	21.00	2,365.38	2,500	2,600	2,560	Do.
	Shamrock:							
7	Section 1	10,661.96	21.00	2,239.02	2,500	2,650	2,640	Do.
8	Section 2	10,826.03	21.00	2,273.46	2,500	2,650	2,485	Do.
9	Section 3	12,076.16	21.00	2,535.99	2,350	2,600	2,450	Do.
10	Section 4	11,823.49	21.00	2,482.93	2,350	2,500	2,460	Do.
11	Section 5	11,437.45	21.00	2,401.87	2,500	2,780	2,550	Do.
12	Section 6	12,769.13	21.00	2,681.52	2,700	3,200	3,050	Do.
	Vaucluse:							
13	Section 1	11,995.38	15.49	1,858.08	3,300	4,000	3,580	Do.
14	Section 2	11,378.99	15.49	1,762.61	3,970	4,580	4,300	Do.
15	Section 3	11,609.30	15.49	1,797.28	4,200	5,150	4,900	Do.
16	Section 4	12,145.70	15.49	1,881.36	5,150	6,000	5,500	Do.
17	Section 5	11,072.18	15.49	1,715.08	6,000	6,400	6,150	Do.
18	Section 6	11,740.99	15.49	1,818.67	5,850	6,200	6,050	Do.
	Roseland:							
19	Section 1	12,222.82	11.50	1,405.62	150	200	175	Do.
20	Section 2	13,055.84	11.50	1,501.42	150	250	175	Stationary.
21	Section 3	12,120.23	11.50	1,393.82	250	400	320	Do.
22	Section 4	12,653.55	11.50	1,455.15	400	500	480	Do.
23	Section 7	13,665.81	11.50	1,571.56	400	550	475	Do.
	Excelsior:							
24	Section 1	11,932.62	11.50	1,372.25	550	1,300	950	Do.
25	Section 2	11,584.20	11.50	1,332.18	1,300	2,150	1,600	Do.
26	Section 3	12,611.77	11.50	1,450.35	2,150	3,350	2,550	Do.
27	Section 4	12,463.72	11.50	1,433.35	3,350	4,500	3,950	Do.
28	Section 5	11,591.33	11.50	1,738.70	4,000	4,200	4,050	Do.
29	Section 6	12,541.26	11.50	1,442.24	4,190	4,250	4,220	Do.
30	Section 7	12,894.73	11.50	1,482.89	3,850	4,150	4,020	Do.
	Wildwood:							
31	Section 4	12,487.27	12.70	1,585.89	3,350	3,600	3,480	Do.
32	Section 5	12,781.89	12.70	1,623.30	3,250	3,500	3,520	Do.
	Home Place:							
33	Section 1	12,681.02	11.50	1,458.31	3,100	3,250	3,180	Do.
34	Section 2	12,721.75	11.50	1,463.00	2,800	3,050	2,925	Do.
35	Section 4	11,968.56	11.50	1,376.38	2,800	2,950	2,880	Do.
36	Section 4	13,249.46	11.50	1,513.88	2,950	3,350	3,200	Do.
37	Section 6	13,920.97	11.50	1,600.91	3,500	3,650	3,520	Do.

Fourth district levees, 1902–3—Continued.

LOWER TENSAS LEVEE DISTRICT—Continued.

No.	Name of levee.	Total yardage paid for.	Price per cubic yard.	Total cost.	Distance from center of levee to river bank. Least.	Greatest.	Average.	Nature of bank.
	Ashland:		*Cents.*		*Feet.*	*Feet.*	*Feet.*	
38	Section 1	11,089.19	11.50	$1,275.25	3,200	3,500	3,350	Caving.
39	Section 2	12,004.29	11.50	1,380.49	2,550	3,200	2,730	Do.
40	Section 3	12,140.16	11.50	1,396.12	2,000	2,600	2,320	Do.
41	Section 4	10,424.21	11.50	1,198.78	1,550	2,000	1,775	Do.
42	Section 5	11,206.64	11.50	1,288.76	1,300	1,550	1,425	Do.

LOWER TENSAS LEVEE DISTRICT (UNCOMPLETED LEVEES).

No.	Name of levee.	Miles below Cairo.	Bank.	Contractor.	Length of line.	Length of axis of river covered.	Grade of levee above highest known water.
	Roseland:				*Feet.*	*Feet.*	*Feet.*
1	Section 5	731	R.	R. T. Clark	1,800	1,740	5
2	Section 6	731	R.	do	1,400	1,850	5
	Wildwood:						
3	Section 1	734	R.	C. H. Whipple	1,360	1,440	5
4	Section 2	734	R.	do	1,100	1,360	5
5	Section 3	734	R.	do	1,400	1,750	5
6	Section 6	735	R.	do	1,200	1,560	5
	Home Place:						
7	Section 5	737	R.	R. T. Clark	900	1,000	5

No.	Name of levee.	Section. Crown.	Land slope.	River slope.	New or enlargement.	Average height— Above old levee.	Above ground surface.	Date of contract.
	Roseland:	*Feet.*				*Feet.*	*Feet.*	
1	Section 5	8	3 to 1	3 to 1	Enlargement	4.5	9.9	July 28, 1902
2	Section 6	8	3 to 1	3 to 1	do	4.8	9.5	Do.
	Wildwood:							
3	Section 1	8	3 to 1	3 to 1	do	5.8	9.6	Nov. 10, 1902
4	Section 2	8	3 to 1	3 to 1	do	6.5	11.5	Do.
5	Section 3	8	3 to 1	3 to 1	do	6.5	9.3	Do.
6	Section 6	8	3 to 1	3 to 1	do	5.0	8.5	Do.
	Home Place:							
7	Section 5	8	3 to 1	3 to 1	do	7.5	11.8	July 28, 1902

No.	Name of levee.	Total yardage.	Price per cubic yard.	Distance from center of levee to river bank. Least.	Greatest.	Average.	Nature of bank.	Condition of contract.
	Roseland:		*Cents.*	*Feet.*	*Feet.*	*Feet.*		
1	Section 5	11,993.39	11.50	450	500	420	Stationary	2 per cent completed.
2	Section 6	12,222.21	11.50	400	450	410	do	39 per cent completed.
	Wildwood:							
3	Section 1	12,567.65	12.70	4,150	4,250	4,175	do	71 per cent completed.
4	Section 2	12,413.73	12.70	3,940	4,250	4,090	do	No work done.
5	Section 3	13,355.00	12.70	3,620	3,940	3,850	do	Do.
6	Section 6	14,017.72	12.70	3,300	3,500	3,375	do	Do.
	Home Place:							
7	Section 5	12,824.15	11.50	3,350	3,640	3,500	do	49 per cent completed.

Fourth district levees, 1902-3—Continued.

ATCHAFALAYA LEVEE DISTRICT.

No.	Name of levee.	Miles below Cairo.	Bank.	Name of contractor.	Length of line.	Length of axis of river covered.	Grade of levee above highest known water.
	Smithland:				*Feet.*	*Feet.*	*Feet.*
1	Section 2	767	R.	Batt O'Brien	1,300	1,470	4.2
2	Section 3	767	R.	do	1,000	1,125	4.3
3	Section 4	767	R.	do	1,300	1,430	4.2
4	Section 5	767	R.	do	1,200	1,340	4.1
5	Section 6	767	R.	do	1,200	1,365	3.9
	Devall:						
6	Section 3	823	R.	Helgason Bros	900	820	4.4
	Cypress Hall:						
7	Section 1	823	R.	do	900	820	4.4
8	Section 2	823	R.	do	800	780	4.4
9	Section 3	823	R.	do	600	540	4.4

No.	Name of levee.	Section.			New or enlargement.	Average height—		Date of contract.	Work completed.
		Crown.	Land slope.	River slope.		Above old levee.	Above ground surface.		
	Smithland:	*Ft.*				*Feet.*	*Feet.*		
1	Section 2	8	3 to 1	3 to 1	Enlargement.	1.4	17.4	Sept. 12, 1902	Dec. 6, 1902
2	Section 3	8	3 to 1	3 to 1	do	2.3	20.1	do	Dec. 2, 1902
3	Section 4	8	3 to 1	3 to 1	do	1.9	17.2	do	Dec. 22, 1902
4	Section 5	8	3 to 1	3 to 1	do	1.8	16.3	do	Mar. 4, 1903
5	Section 6	8	3 to 1	3 to 1	do	1.3	16.3	do	Do.
	Devall:								
6	Section 3	8	3 to 1	3 to 1	do	3.2	19.1	July 1, 1902	Sept. 8, 1902
	Cypress Hall:								
7	Section 1	8	3 to 1	3 to 1	do	3.1	19.2	do	Do.
8	Section 2	8	3 to 1	3 to 1	do	3.0	21.4	do	Sept. 18, 1902
9	Section 3	8	3 to 1	3 to 1	do	2.9	22.3	do	Aug. 5, 1902

No.	Name of levee.	Total yardage paid for.	Price per cubic yard.	Total cost.	Distance from center of levee to river bank.			Nature of bank.
					Least.	Greatest.	Average.	
	Smithland:		*Cents.*		*Feet.*	*Feet.*	*Feet.*	
1	Section 2	12,182.74	14.73	$1,794.52	665	1,250	950	Caving.
2	Section 3	12,396.28	14.73	1,825.97	1,250	1,440	1,360	Do.
3	Section 4	12,514.66	14.73	1,843.41	1,040	1,425	1,320	Do.
4	Section 5	12,107.18	14.73	1,783.39	1,000	2,800	2,000	Do.
5	Section 6	12,568.19	14.73	1,851.29	2,800	4,400	3,600	Do.
	Devall:							
6	Section 3	13,253.54	20.50	2,716.98	900	1,340	1,160	Do.
	Cypress Hall:							
7	Section 1	15,994.61	20.50	3,278.90	900	1,060	980	Do.
8	Section 2	14,320.42	20.50	2,935.69	1,030	1,120	1,080	Do.
9	Section 3	15,514.41	20.50	3,180.45	1,120	1,230	1,170	Do.

Fourth district levees, 1902-3—Continued.

ATCHAFALAYA LEVEE DISTRICT (UNCOMPLETED LEVEES).

lo.	Name of levee.	Miles below Cairo.	Bank.	Contractor.	Length of line.	Length of axis of river covered.	Grade of levee above highest known water.
	Red River Landing:				*Feet.*	*Feet.*	*Feet.*
1	Section 1	766	R.	Jas. R. Marlow	1,105	1,250	4.3
2	Section 2	766	R.	do	1,000	1,180	4.3
3	Section 3	766	R.	do	1,000	1,205	4.3
4	Section 4	766	R.	do	1,000	1,185	4.2
5	Section 5	766	R.	do	1,100	1,250	4.2
6	Section 6	766	R.	do	700	825	4.2
	Smithland:						
7	Section 1	767	R.	Batt O'Brien	1,183	1,310	4.2
	Henriette:						
8	Section 1	768	R.		11,300	1,410	3.8
9	Section 2	768	R.		1,600	1,790	3.7
0	Section 3	768	R.		1,400	1,550	3.5
1	Section 4	768	R.		1,500	1,615	3.6
2	Section 5	768	R.		1,300	1,485	3.8
3	Section 6	768	R.		1,700	1,810	3.8

o.	Name of levee.	Section.			New or enlargement.	Average height—		Date of contract.
		Crown.	Land slope.	River slope.		Above old levee.	Above ground surface.	
	Red River Landing:	*Feet.*				*Feet.*	*Feet.*	
	Section 1	8	3 to 1	3 to 1	Enlargement	2.8	18.5	Dec. 11, 1902
	Section 2	8	3 to 1	3 to 1	do	2.4	19.7	Do.
	Section 3	8	3 to 1	3 to 1	do	2.2	20.8	Do.
	Section 4	8	3 to 1	3 to 1	do	1.9	20.3	Do.
	Section 5	8	3 to 1	3 to 1	do	2.3	20.7	Do.
	Section 6	8	3 to 1	3 to 1	do	2.7	20.6	Do.
	Smithland:							
	Section 1	8	3 to 1	3 to 1	do	2.1	16.9	Sept. 12, 1902
	Henriette:							
	Section 1	8	3 to 1	3 to 1	do	1.3	17.7	Nov. 10, 1902
	Section 2	8	3 to 1	3 to 1	do	.9	17.4	Do.
	Section 3	8	3 to 1	3 to 1	do	.8	17.2	Do.
	Section 4	8	3 to 1	3 to 1	do	1.1	14.7	Do.
	Section 5	8	3 to 1	3 to 1	do	1.2	16.8	Do.
	Section 6	8	3 to 1	3 to 1	do	1.1	16.1	Do.

	Name of levee.	Total yardage.	Price per cubic yard.	Distance from center of levee to river bank.			Nature of bank.	Condition of contract.
				Least.	Greatest.	Average.		
	Red River Landing:		*Cents.*	*Feet.*	*Feet.*	*Feet.*		
	Section 1	12,903.52	19.25	675	1,040	856	Caving	Nothing done.
	Section 2	13,258.77	19.25	1,040	1,130	1,070	do	Do.
	Section 3	13,029.75	19.25	1,120	1,130	1,125	do	Do.
	Section 4	12,258.21	19.25	1,120	1,215	1,160	do	Do.
	Section 5	12,766.10	19.25	1,100	1,310	1,200	do	Do.
	Section 6	11,340.33	19.25	1,315	1,350	1,325	do	Do.
	Smithland:							
	Section 1	13,795.45	14.73	670	1,380	1,030	do	About 6 per cent completed.
	Henriette:							
	Section 1	12,298.37	17.50	4,400	8,000	6,500	do	Nothing done.
	Section 2	12,451.50	17.50	8,000	12,000	9,900	do	Do.
	Section 3	12,574.21	17.50	12,000	14,500	13,300	do	Do.
	Section 4	12,967.23	17.50	14,500	16,000	15,300	do	Do.
	Section 5	12,466.39	17.50	16,000	18,500	17,300	do	Do.
	Section 6	12,421.97	17.50	18,500	22,000	20,500	do	Do.

Fourth district levees, 1902-3—Continued.

LAFOURCHE LEVEE DISTRICT (UNCOMPLETED LEVEES).

No.	Name of levee.	Miles below Cairo.	Bank.	Contractor.	Length of line.	Length of axis of river covered.	Grade of levee above highest known water
	St. James:				*Feet.*	*Feet.*	*Feet.*
1	Section 1	904	R.	Menzies & Co.	1,312	1,180	3.9
2	Section 2	904	R.	do	1,300	1,170	3.9
3	Section 3	904	R.	do	1,290	1,160	3.9
4	Section 4	904	R.	do	1,100	990	3.9
5	Section 5	904	R.	do	1,200	1,080	3.9
6	Section 6	904	R.	do	1,444	1,300	3.8
	Chopin:						
7	Section 1	906	R.	do	1,500	1,500	3.9
8	Section 2	906	R.	do	1,696	1,696	3.9

No.	Name of levee.	Section.			New or enlargement.	Average height—		Date of contract.
		Crown.	Land slope.	River slope.		Above old levee.	Above ground surface.	
	St. James:	*Feet.*				*Feet.*	*Feet.*	
1	Section 1	8	3 to 1	3 to 1	Enlargement	2.3	13.8	Dec. 3, 1902.
2	Section 2	8	3 to 1	3 to 1	do	2.4	14.3	Do.
3	Section 3	8	3 to 1	3 to 1	do	2.4	15.1	Do.
4	Section 4	8	3 to 1	3 to 1	do	2.4	16.1	Do.
5	Section 5	8	3 to 1	3 to 1	do	2.2	13.6	Do.
6	Section 6	8	3 to 1	3 to 1	do	2.1	11.7	Do.
	Chopin:							
7	Section 1	8	3 to 1	3 to 1	do	2.0	14.1	Do.
8	Section 2	8	3 to 1	3 to 1	do	1.8	15.2	Do.

No.	Name of levee.	Total yardage.	Price per cubic yard.	Distance from center of levee to river bank.			Nature of bank.	Condition of contract.
				Least.	Greatest.	Average.		
	St. James:		*Cents.*	*Feet.*	*Feet.*	*Feet.*		
1	Section 1	12,748.22	14.50	320	450	400	Caving	Nothing done.
2	Section 2	13,494.73	14.50	375	525	450	do	Do.
3	Section 3	12,678.22	14.50	340	525	420	do	Do.
4	Section 4	13,254.17	14.50	270	380	330	do	Do.
5	Section 5	12,528.08	14.50	290	365	325	do	Do.
6	Section 6	13,593.49	14.50	165	390	260	do	Do.
	Chopin:							
7	Section 1	12,966.73	14.50	600	730	660	Washing	Do.
8	Section 2	13,025.91	14.50	570	765	595	do	Do.

BARATARIA LEVEE DISTRICT.

No.	Name of levee.	Miles below Cairo.	Bank.	Contractor.	Length of line.	Length of axis of river covered.	Grade of levee above highest known water.
	Concession:				*Feet.*	*Feet.*	*Feet.*
1	Section 1	987	R.	Geo. H. Conrad	2,900	2,810	3.2

Fourth district levees, 1902-3—Continued.

BARATARIA LEVEE DISTRICT—Continued.

No.	Name of levee.	Section.			New or enlargement.	Average height—		Date of contract.	Work completed.
		Crown.	Land slope.	River slope.		Above old levee.	Above ground surface.		
		Ft.				*Feet.*	*Feet.*		
1	Concession: Section 1	8	3 to 1	3 to 1	Enlargement	1.5	7.9	July 26, 1902	Feb. 12, 1903

No.	Name of levee.	Yardage paid for.	Price per cubic yard.	Total cost.	Distance from center of levee to river bank.			Nature of bank.
					Least.	Greatest.	Average.	
			Cents.		*Feet.*	*Feet.*	*Feet.*	
1	Concession: Section 1	12,285.19	14.75	$1,812.06	87	250	185	Caving.

BARATARIA LEVEE DISTRICT (UNCOMPLETED LEVEES).

No.	Name of levee.	Miles below Cairo.	Bank.	Contractor.	Length of line.	Length of axis of river covered.	Grade of levee above highest known water.
	Concession:				*Feet.*	*Feet.*	*Feet.*
1	Section 2	987	R.	George H. Conrad	2,500	2,390	3.2
2	Section 3	987	R.	do	2,140	2,030	3.1

No.	Name of levee.	Section.			New or enlargement.	Average height—		Date of contract.	Total yardage.
		Crown.	Land slope.	River slope.		Above old levee.	Above ground surface.		
	Concession:	*Ft.*				*Feet.*	*Feet.*		
1	Section 2	8	3 to 1	3 to 1	Enlargement.	1.5	8.7	July 26, 1902	13,115.68
2	Section 3	8	3 to 1	3 to 1	do	1.7	10.0	do	12,873.90

o.	Name of levee.	Price per cubic yard.	Distance from center of levee to river bank.			Nature of bank.	Condition of contract.
			Least.	Greatest.	Average.		
	Concession:	*Cents.*	*Feet.*	*Feet.*	*Feet.*		
1	Section 2	14.75	100	235	195	Caving	90 per cent completed.
2	Section 3	14.75	190	208	190	do	Do.

Fourth district levees, 1902–3—Continued.

PONTCHARTRAIN LEVEE DISTRICT.

No.	Name of levee.	Miles below Cairo.	Bank.	Contractor.	Length of line.	Length of axis of river covered.	Grade of levee above highest known water.
					Feet.	*Feet.*	*Feet.*
	Virginia:						
1	Section 1	868.5	L.	C. D. Leeper	1,120	1,100	4.1
2	Section 2	868.5	L.	do	1,200	1,189	4.1
3	Section 3	868.5	L.	do	1,100	1,000	4.1
4	Section 4	868.5	L.	do	1,000	965	4.1
5	Section 5	868.5	L.	do	1,000	980	4.1
6	Section 6	868.5	L.	do	1,210	1,185	4.1
	Ophelia:						
7	Section 1	865	L.	do	738	748	4.1
8	Section 2	865	L.	do	800	825	4.1
9	Section 3	865	L.	do	742	765	4.1
	Gem:						
10	Section 1	881	L.	Helgason Bros	710	695	4.2
11	Section 2	881	L.	do	1,000	990	4.2
12	Section 3	881	L.	do	1,200	1,180	4.2
13	Section 4	881	L.	do	1,200	1,195	4.2
14	Section 5	881	L.	do	1,300	1,295	4.2
	81-Mile Point:						
15	Section 3	883	L.	C. D. Leeper	1,200	1,240	4.2
16	Section 4	883	L.	do	1,100	1,145	4.2
17	Section 5	883	L.	do	1,012	1,060	4.2
	St. Mary Chapel:						
18	Section 1	895	L.	James R. Marlow	1,200	1,225	4.1
19	Section 2	895	L.	do	1,200	1,215	4.1
20	Section 3	895	L.	do	1,000	1,030	4.1
21	Section 4	895	L.	do	900	935	4.1
22	Section 5	895	L.	do	900	945	4.1
	Whitehall:						
23	Section 1	895	L.	do	1,200	1,240	4.1
24	Section 2	895	L.	do	900	940	4.2
25	Section 3	895	L.	do	1,200	1,250	4.2
26	Section 4	895	L.	do	900	935	4.1
27	Section 5	895	L.	do	900	935	4.2
	Alta Villa:						
28	Section 1	898	L.	Menzies & Co	1,000	1,040	4.2
29	Section 2	898	L.	do	1,000	1,045	4.1
30	Section 3	898	L.	do	1,000	1,040	4.2
31	Section 4	898	L.	do	1,100	1,150	4.1
32	Section 5	898	L.	do	1,100	1,165	4.2
	Rapidan:						
33	Section 1	899	L.	do	1,200	1,250	4.1
34	Section 2	899	L.	do	1,000	1,045	4.1
35	Section 3	899	L.	do	1,000	1,055	4.2
36	Section 4	899	L.	do	1,200	1,240	4.2
37	Section 5	899	L.	do	1,138	1,160	4.2
	Golden Grove:						
38	Section 1	914.5	L.	do	1,200	1,190	4.2
39	Section 2	914.5	L.	do	1,200	1,190	4.1
40	Section 3	914.5	L.	do	1,100	1,095	4.1
41	Section 4	914.5	L.	do	1,100	1,080	4.1
42	Section 5	914.5	L.	do	1,100	1,090	4.1
	Sport:						
43	Section 1	915	L.	do	1,100	1,080	4.1
44	Section 2	915	L.	do	1,200	1,175	4.1
45	Section 3	915	L.	do	1,000	990	4.0
46	Section 4	915	L.	do	1,000	985	4.0
47	Section 5	915	L.	do	1,000	865	4.1
	Mount Airey:						
48	Section 1	916	L.	do	900	865	4.1
49	Section 2	916	L.	do	1,100	1,070	4.1
50	Section 3	916	L.	do	800	760	4.1
51	Section 4	916	L.	do	800	750	4.1
52	Section 5	916	L.	do	800	780	4.1

Fourth district levees, 1902–3—Continued.

PONTCHARTRAIN LEVEE DISTRICT—Continued.

No.	Name of levee.	Section.			New or enlargement.	Average height—		Date of contract.	Work completed.
		Crown.	Land slope.	River slope.		Above old levee.	Above ground surface.		
	Virginia:	*Ft.*				*Feet.*	*Feet.*		
1	Section 1	8	3 to 1	3 to 1	Enlargement.	2.4	16.3	July 22, 1902	Sept. 5, 1902
2	Section 2	8	3 to 1	3 to 1	do	2.1	15.3	do	Do.
3	Section 3	8	3 to 1	3 to 1	do	2.7	14.0	do	Nov. 19, 1902
4	Section 4	8	3 to 1	3 to 1	do	3.1	14.2	do	Dec. 4, 1902
5	Section 5	8	3 to 1	3 to 1	do	3.3	12.9	do	Oct. 20, 1902
6	Section 6	8	3 to 1	3 to 1	do	3.2	13.6	do	Sept. 24, 1902
	Ophelia:								
7	Section 1	8	3 to 1	3 to 1	do	2.6	15.0	do	Oct. 28, 1902
8	Section 2	8	3 to 1	3 to 1	do	2.5	14.7	do	Nov. 17, 1902
9	Section 3	8	3 to 1	3 to 1	do	2.4	15.6	do	Feb. 17, 1903
	Gem:								
10	Section 1	8	3 to 1	3 to 1	do	3.0	13.5	do	Oct. 30, 1902
11	Section 2	8	3 to 1	3 to 1	do	3.3	15.5	do	Nov. 22, 1902
12	Section 3	8	3 to 1	3 to 1	do	2.8	15.9	do	Dec. 26, 1902
13	Section 4	8	3 to 1	3 to 1	do	2.9	16.3	do	Jan. 12, 1903
14	Section 5	8	3 to 1	3 to 1	do	3.0	15.5	do	Oct. 2, 1902
	31-Mile Point:								
15	Section 3	8	3 to 1	3 to 1	do	2.7	13.5	do	Feb. 4, 1903
16	Section 4	8	3 to 1	3 to 1	do	3.0	14.3	do	Jan. 24, 1903
17	Section 5	8	3 to 1	3 to 1	do	3.3	15.2	do	Jan. 2, 1903
	St. Mary Chapel:								
18	Section 1	8	3 to 1	3 to 1	do	3.7	11.4	Mar. 12, 1902	Aug. 7, 1902
19	Section 2	8	3 to 1	3 to 1	do	3.6	12.0	do	Do.
20	Section 3	8	3 to 1	3 to 1	do	3.3	12.6	do	July 24, 1902
21	Section 4	8	3 to 1	3 to 1	do	4.0	13.4	do	July 3, 1902
22	Section 5	8	3 to 1	3 to 1	do	4.2	12.9	do	July 12, 1902
	Whitehall:								
23	Section 1	8	3 to 1	3 to 1	do	3.6	13.2	May 23, 1902	Feb. 13, 1903
24	Section 2	8	3 to 1	3 to 1	do	3.6	13.8	do	Feb. 2, 1903
25	Section 3	8	3 to 1	3 to 1	do	3.0	12.1	do	Jan. 15, 1903
26	Section 4	8	3 to 1	3 to 1	do	3.9	14.1	do	Jan. 9, 1903
27	Section 5	8	3 to 1	3 to 1	do	3.9	14.2	do	Do.
	Alta Villa:								
28	Section 1	8	3 to 1	3 to 1	do	3.3	14.2	July 22, 1902	Nov. 24, 1902
29	Section 2	8	3 to 1	3 to 1	do	3.7	13.8	do	Nov. 18, 1902
30	Section 3	8	3 to 1	3 to 1	do	3.7	13.9	do	Nov. 1, 1902
31	Section 4	8	3 to 1	3 to 1	do	3.5	13.7	do	Oct. 23, 1902
32	Section 5	8	3 to 1	3 to 1	do	3.3	12.8	do	Oct. 9, 1902
	Rapidan:								
33	Section 1	8	3 to 1	3 to 1	do	3.4	12.5	do	Sept. 29, 1902
34	Section 2	8	3 to 1	3 to 1	do	3.2	14.9	do	Sept. 13, 1902
35	Section 3	8	3 to 1	3 to 1	do	3.4	13.4	do	Sept. 2, 1902
36	Section 4	8	3 to 1	3 to 1	do	3.2	12.6	do	Aug. 20, 1902
37	Section 5	8	3 to 1	3 to 1	do	3.3	12.5	do	Aug. 5, 1902
	Golden Grove:								
8	Section 1	8	3 to 1	3 to 1	do	2.5	11.1	do	Sept. 6, 1902
9	Section 2	8	3 to 1	3 to 1	do	2.8	10.9	do	Jan. 30, 1903
0	Section 3	8	3 to 1	3 to 1	do	2.7	11.9	do	Sept. 24, 1902
1	Section 4	8	3 to 1	3 to 1	do	2.6	12.8	do	Oct. 2, 1902
2	Section 5	8	3 to 1	3 to 1	do	2.7	13.6	do	Oct. 10, 1902
	Sport:								
3	Section 1	8	3 to 1	3 to 1	do	3.1	11.3	do	Oct. 31, 1902
4	Section 2	8	3 to 1	3 to 1	do	2.7	10.9	do	Nov. 15, 1902
5	Section 3	8	3 to 1	3 to 1	do	2.7	12.4	do	Do.
6	Section 4	8	3 to 1	3 to 1	do	3.1	12.0	do	Nov. 29, 1902
7	Section 5	8	3 to 1	3 to 1	do	3.3	11.5	do	Dec. 13, 1902
	Mount Airey:								
8	Section 1	8	3 to 1	3 to 1	do	3.4	13.0	do	Dec. 23, 1902
9	Section 2	8	3 to 1	3 to 1	do	3.6	12.5	do	Dec. 30, 1902
0	Section 3	8	3 to 1	3 to 1	do	3.8	15.1	do	Part comp.
1	Section 4	8	3 to 1	3 to 1	do	3.5	15.1		
2	Section 5	8	3 to 1	3 to 1	do	4.0	15.0		

Fourth district levees, 1902–3—Continued.

PONTCHARTRAIN LEVEE DISTRICT—Continued.

No.	Name of levee.	Total yardage paid for.	Price per cubic yard.	Total cost.	Distance from center of levee to river bank.			Nature of bank.
					Least.	Greatest.	Average.	
	Virginia:		*Cents.*		*Feet.*	*Feet.*	*Feet.*	
1	Section 1	12,899.42	13⅞	$1,789.79	285	583	435	Caving.
2	Section 2	12,959.26	13⅞	1,798.09	294	583	440	Do.
3	Section 3	12,577.45	13⅞	1,745.12	110	291	240	Do.
4	Section 4	12,923.73	13⅞	1,793.17	102	183	140	Do.
5	Section 5	12,370.26	13⅞	1,716.37	110	183	145	Do.
6	Section 6	13,506.58	13⅞	1,874.04	175	218	190	Do.
	Ophelia:							
7	Section 1	10,577.24	13⅞	1,467.59	165	300	180	Stationary.
8	Section 2	11,065.47	13⅞	1,535.33	200	215	205	Do.
9	Section 3	11,143.02	13⅞	1,546.09	200	220	205	Do.
	Gem:							
10	Section 1	12,903.17	15.50	1,999.99	379	510	435	Caving.
11	Section 2	12,920.77	15.50	2,002.72	522	595	560	Do.
12	Section 3	13,201.84	15.50	2,046.29	530	580	550	Do.
13	Section 4	12,889.46	15.50	1,997.87	530	830	810	Do.
14	Section 5	13,854.25	15.50	2,147.41	615	710	660	Do.
	81-Mile Point:							
15	Section 3	13,307.88	13.49	1,795.23	580	640	600	Stationary.
16	Section 4	13,047.09	13.49	1,760.05	300	550	430	Do.
17	Section 5	13,856.54	13.49	1,869.24	155	295	230	Do.
	St. Mary Chapel:							
18	Section 1	11,885.31	11.00	1,307.39	180	210	195	Washing.
19	Section 2	12,167.98	11.00	1,338.48	147	180	165	Do.
20	Section 3	10,604.98	11.00	1,166.55	112	200	155	Do.
21	Section 4	11,082.24	11.00	1,219.05	190	210	200	Do.
22	Section 5	9,901.89	11.00	1,089.21	170	220	195	Do.
	Whitehall:							
23	Section 1	12,777.51	12.88	1,645.74	200	225	210	Stationary.
24	Section 2	12,086.55	12.88	1,556.74	180	200	190	Do.
25	Section 3	12,985.62	12.88	1,672.55	195	480	335	Do.
26	Section 4	12,561.10	12.88	1,617.87	475	700	580	Do.
27	Section 5	12,007.03	12.88	1,546.50	690	730	710	Washing.
	Alta Villa:							
28	Section 1	12,106.53	13.25	1,604.12	600	680	640	Do.
29	Section 2	13,020.85	13.25	1,725.26	500	600	550	Do.
30	Section 3	12,694.80	13.25	1,682.06	345	500	420	Do.
31	Section 4	14,047.54	13.25	1,861.30	290	340	315	Do.
32	Section 5	12,985.86	13.25	1,720.63	120	280	200	Do.
	Rapidan:							
33	Section 1	13,969.57	13.25	1,850.97	110	380	245	Stationary
34	Section 2	12,982.38	13.25	1,720.17	280	460	270	Do.
35	Section 3	12,305.81	13.25	1,630.52	280	460	270	Do.
36	Section 4	13,997.30	13.25	1,854.64	230	340	310	Do.
37	Section 5	13,267.96	13.25	1,758.00	210	230	220	Do.
	Golden Grove:							
38	Section 1	10,778.98	13.25	1,428.21	190	280	230	Washing.
39	Section 2	10,798.26	13.25	1,430.77	110	200	150	Do.
40	Section 3	10,423.52	13.25	1,381.11	115	240	170	Do.
41	Section 4	10,628.11	13.25	1,408.23	180	250	215	Do.
42	Section 5	10,632.08	13.25	1,408.74	170	225	190	Do.
	Sport:							
43	Section 1	10,426.67	13.25	1,381.53	160	370	260	Caving.
44	Section 2	10,103.08	13.25	1,338.66	210	300	350	Do.
45	Section 3	10,120.39	13.25	1,340.95	190	230	210	Do.
46	Section 4	10,531.45	13.25	1,395.42	170	200	185	Do.
47	Section 5	11,076.66	13.25	1,467.66	200	260	230	Do.
	Mount Airey:							
48	Section 1	9,680.38	13.25	1,282.65	230	330	280	Do.
49	Section 2	11,218.20	13.25	1,486.41	310	370	340	Do.
50	Section 3	20,000.00	13.25	2,650.00	390	420	400	Do.
51	Section 4				420	450	435	Do.
52	Section 5				450	550	500	Do.

Fourth district levees, 1902–3—Continued.

PONTCHARTRAIN LEVEE DISTRICT (UNCOMPLETED LEVEES).

No.	Name of levee.	Miles below Cairo.	Bank.	Contractor.	Length of line.	Length of axis of river covered.	Grade of levee above highest known water.
	Dicharry:				*Feet.*	*Feet.*	*Feet.*
1	Section 1	882	L.	C. D. Leeper	1,100	1,100	4.2
2	Section 2	882	L.	do	1,000	1,000	4.2
3	Section 3	882	L.	do	1,200	1,200	4.2
4	Section 4	882	L.	do	1,100	1,100	3.9
5	Section 5	882	L.	do	1,000	1,000	3.8
	81-Mile Point:						
6	Section 1	883	L.	do	1,100	1,100	4.1
7	Section 2	883	L.	do	1,300	1,320	4.2
	Uncle Sam:						
8	Section 1	901	L.	R. T. Clark	1,225	1,220	4.0
9	Section 2	901	L.	do	1,200	1,195	3.9
10	Section 3	901	L.	do	1,288	1,278	3.9
11	Section 4	901	L.	do	1,068	1,062	4.0
12	Section 5	901	L.	do	1,300	1,295	4.0
	Convent:						
13	Section 1	903	L.	do	1,302	1,302	4.0
14	Section 2	903	L.	do	1,201	1,210	4.1
15	Section 3	903	L.	do	1,200	1,200	4.1
16	Section 4	903	L.	do	1,200	1,200	4.0
17	Section 5	903	L.	do	1,274	1,274	3.8
	College Point:						
18	Section 1	904	L.	do	1,200	1,300	3.9
19	Section 2	904	L.	do	1,401	1,300	3.8
20	Section 3	904	L.	do	1,208	3,000	3.8
	Belmont:						
21	Section 1	908	L.	do	1,280	1,200	3.8
22	Section 2	908	L.	do	1,201	1,120	3.8
23	Section 3	908	L.	do	702	660	4.0
24	Section 4	908	L.	do	1,100	1,000	3.9
	Hester:						
25	Section 1	909	L.	do	999	950	3.8
26	Section 2	909	L.	do	1,126	1,070	3.8
27	Section 3	909	L.	do	1,364	1,300	3.7
28	Section 4	909	L.	do	1,414	1,340	3.8
	Poche:						
29	Section 1	911	L.	do	1,264	1,264	3.8
30	Section 2	911	L.	do	1,298	1,298	3.8
31	Section 3	911	L.	do	1,300	1,300	3.7
32	Section 4	911	L.	do	1,466	1,466	3.8
	St. Joseph Church:						
33	Section 1	912	L.	do	1,298	1,298	3.8
34	Section 2	912	L.	do	1,300	1,300	3.8
35	Section 3	912	L.	do	1,381	1,381	3.8
36	Section 4	912	L.	do	1,182	1,182	3.8
	Mount Airey:						
37	Section 3	916	L.	Menzies & Co	800	760	4.1
38	Section 4	916	L.	do	800	750	4.1
39	Section 5	916	L.	do	819	780	4.1
	Angelina:						
0	Section 1	917	L.	R. T. Clark	881	880	3.8
1	Section 2	917	L.	do	900	858	3.8
2	Section 3	917	L.	do	835	790	3.7
	La Place:						
3	Section 1	927	L.	do	1,801	1,700	3.6
4	Section 2	927	L.	do	1,800	1,700	3.6
5	Section 3	927	L.	do	1,998	1,890	3.5
6	Section 4	927	L.	do	2,100	2,000	3.6
7	Section 5	927	L.	do	2,188	2,000	3.6

Fourth district levees, 1902–3—Continued.

PONTCHARTRAIN LEVEE DISTRICT (UNCOMPLETED LEVEES).

No.	Name of levee.	Section.			New or enlargement.	Average height—		Date of contract.
		Crown.	Land slope.	River slope.		Above old levee.	Above ground surface.	
	Dicharry:	*Feet.*				*Feet.*	*Feet.*	
1	Section 1	8	3 to 1	3 to 1	Enlargement	3.5	16.4	July 22, 1902.
2	Section 2	8	3 to 1	3 to 1	do	3.4	17.9	Do.
3	Section 3	8	3 to 1	3 to 1	do	2.8	18.7	Do.
4	Section 4	8	3 to 1	3 to 1	do	2.6	16.9	Do.
5	Section 5	8	3 to 1	3 to 1	do	3.2	14.1	Do.
	81-Mile Point:							
6	Section 1	8	3 to 1	3 to 1	do	3.5	14.8	Do.
7	Section 2	8	3 to 1	3 to 1	do	2.8	12.7	Do.
	Uncle Sam:							
8	Section 1	8	3 to 1	3 to 1	do	2.9	18.1	Feb. 24, 1903
9	Section 2	8	3 to 1	3 to 1	do	3.4	12.5	Do.
10	Section 3	8	3 to 1	3 to 1	do	3.5	12.3	Do.
11	Section 4	8	3 to 1	3 to 1	do	3.2	12.2	Do.
12	Section 5	8	3 to 1	3 to 1	do	3.4	12.0	Do.
	Convent:							
13	Section 1	8	3 to 1	3 to 1	do	3.2	13.1	Do.
14	Section 2	8	3 to 1	3 to 1	do	3.4	13.0	Do.
15	Section 3	8	3 to 1	3 to 1	do	3.3	12.5	Do.
16	Section 4	8	3 to 1	3 to 1	do	3.3	13.8	Do.
17	Section 5	8	3 to 1	3 to 1	do	3.8	13.6	Do.
	College Point:							
18	Section 1	8	3 to 1	3 to 1	do	3.0	12.1	Do.
19	Section 2	8	3 to 1	3 to 1	do	3.0	11.5	Do.
20	Section 3	8	3 to 1	3 to 1	do	2.1	13.1	Do.
	Belmont:							
21	Section 1	8	3 to 1	3 to 1	do	2.7	15.5	Do.
22	Section 2	8	3 to 1	3 to 1	do	3.0	15.6	Do.
23	Section 3	8	3 to 1	3 to 1	do	3.4	13.3	Do.
24	Section 4	8	3 to 1	3 to 1	do	2.6	15.4	Do.
	Hester:							
25	Section 1	8	3 to 1	3 to 1	do	2.7	16.5	Do.
26	Section 2	8	3 to 1	3 to 1	do	2.9	15.4	Do.
27	Section 3	8	3 to 1	3 to 1	do	2.0	13.6	Do.
28	Section 4	8	3 to 1	3 to 1	do	2.7	18.4	Do.
	Poche:							
29	Section 1	8	3 to 1	3 to 1	do	3.2	10.5	Do.
30	Section 2	8	3 to 1	3 to 1	do	3.1	11.5	Do.
31	Section 3	8	3 to 1	3 to 1	do	3.1	11.8	Do.
32	Section 4	8	3 to 1	3 to 1	do	2.5	10.8	Do.
	St. Joseph Church:							
33	Section 1	8	3 to 1	3 to 1	do	2.6	11.3	Do.
34	Section 2	8	3 to 1	3 to 1	do	2.9	11.5	Do.
35	Section 3	8	3 to 1	3 to 1	do	3.1	10.6	Do.
36	Section 4	8	3 to 1	3 to 1	do	3.3	10.9	Do.
	Mount Airey:							
37	Section 3	8	3 to 1	3 to 1	do	3.8	15.1	July 22, 1902.
38	Section 4	8	3 to 1	3 to 1	do	3.5	15.1	Do.
39	Section 5	8	3 to 1	3 to 1	do	4.0	15.0	Do.
	Angelina:							
40	Section 1	8	3 to 1	3 to 1	do	3.4	18.9	Feb. 24, 1903.
41	Section 2	8	3 to 1	3 to 1	do	3.2	19.1	Do.
42	Section 3	8	3 to 1	3 to 1	do	3.6	19.0	Do.
	La Place:							
43	Section 1	8	3 to 1	3 to 1	do	2.9	13.5	Do.
44	Section 2	8	3 to 1	3 to 1	do	3.0	12.8	Do.
45	Section 3	8	3 to 1	3 to 1	do	2.6	12.4	Do.
46	Section 4	8	3 to 1	3 to 1	do	2.2	11.7	Do.
47	Section 5	8	3 to 1	3 to 1	do	1.9	10.8	Do.

Fourth district levees, 1902-3—Continued.

PONTCHARTRAIN LEVEE DISTRICT (UNCOMPLETED LEVEES).

No.	Name of levee.	Total yardage.	Price per cubic yard.	Distance from center of levee to river bank.			Nature of bank.	Condition of contract.
				Least.	Greatest.	Average.		
			Cents.	*Feet.*	*Feet.*	*Feet.*		
	Dicharry:							
1	Section 1	13,930.74	13.49	494	650	570	Caving	No work done.
2	Section 2	13,088.82	13.49	560	650	600	do	Do.
3	Section 3	13,882.63	13.49	545	600	570	do	Do.
4	Section 4	12,220.05	13.49	285	595	420	do	Do.
5	Section 5	12,372.98	13.49	330	520	425	do	Do.
	81-Mile Point:							
6	Section 1	13,054.11	13.49	416	1,155	780	Stationary	Do.
7	Section 2	13,317.17	13.49	580	1,090	835	do	73 per cent in place.
	Uncle Sam:							
8	Section 1	12,579.93	12.72	250	320	275	do	No work done.
9	Section 2	12,709.40	12.72	230	270	250	do	Do.
10	Section 3	13,325.22	12.72	140	250	175	do	Do.
11	Section 4	11,302.47	12.72	120	160	140	do	Do.
12	Section 5	12,735.67	12.72	130	150	140	do	Do.
	Convent:							
13	Section 1	13,279.23	13.95	120	170	140	Washing	Do.
14	Section 2	12,203.72	13.95	150	210	180	do	Do.
15	Section 3	12,711.31	13.95	115	215	160	do	Do.
16	Section 4	12,563.39	13.95	120	145	130	do	Do.
17	Section 5	12,466.91	13.95	90	220	140	Caving	Do.
	College Point:							
18	Section 1	12,972.17	13.95	90	150	120	Stationary	Do.
19	Section 2	12,532.26	13.95	77	190	105	do	Do.
20	Section 3	11,057.43	13.95	160	350	230	do	Do.
	Belmont:							
21	Section 1	13,850.06	13.45	500	560	510	Caving	Do.
22	Section 2	13,906.84	13.45	460	590	515	do	Do.
23	Section 3	14,249.57	13.45	450	490	470	Stationary	Do.
24	Section 4	13,357.48	13.45	430	450	440	do	Do.
	Hester:							
25	Section 1	13,192.53	13.45	430	550	565	do	Do.
26	Section 2	13,685.89	13.45	350	675	495	Caving	Do.
27	Section 3	13,544.55	13.45	285	500	380	do	Do.
28	Section 4	13,403.41	13.45	410	475	435	do	Do.
	Poche:							
29	Section 1	10,571.78	12.72	260	280	270	Stationary	Do.
30	Section 2	11,288.21	12.72	150	260	235	Caving	Do.
31	Section 3	11,123.26	12.72	110	175	135	Washing	Do.
32	Section 4	11,446.91	12.72	110	180	140	Caving	Do.
	St. Joseph Church:							
33	Section 1	11,411.68	12.72	120	170	143	Washing	Do.
34	Section 2	11,460.91	12.72	95	140	110	do	Do.
35	Section 3	11,597.00	12.72	100	180	130	do	Do.
36	Section 4	11,120.65	12.72	130	170	150	do	Do.
	Mount Airey:							
37	Section 3	10,000.56	13.25	390	420	400	Caving	84 per cent in place.
38	Section 4	10,189.75	13.25	420	450	435	do	65 per cent in place.
39	Section 5	10,461.44	13.25	450	350	500	do	67 per cent in place.
	Angelina:							
40	Section 1	11,354.90	24.87	490	550	520	do	No work done.
41	Section 2	11,372.24	24.87	493	537	510	do	Do.
42	Section 3	11,218.17	24.87	525	560	530	do	Do.
	La Place:							
43	Section 1	13,333.04	12.72	260	415	345	Stationary	Do.
44	Section 2	13,573.15	12.72	360	408	370	do	Do.
45	Section 3	13,178.61	12.72	390	445	410	Washing	Do.
46	Section 4	13,424.13	12.72	350	480	405	do	Do.
47	Section 5	13,122.52	12.72	240	492	345	do	Do.

Fourth district levees, 1902–3.—Continued.

LAKE BORGNE LEVEE DISTRICT.

No.	Name of levee.	Miles below Cairo.	Bank.	Contractor.	Length of line.	Length of axis of river covered.	Grade of levee above highest known water.
	Scarsdale:				*Feet.*	*Feet.*	*Feet.*
1	Section 1	985	L.	W. F. Barbour & Son	700	450	3
2	Section 2	985	L.	do	800	800	3
3	Section 3	985	L.	do	836	750	3
	Savoie:						
4	Section 1	1,008	L.	A. Leopold	2,900	2,900	3
5	Section 2	1,008	L.	do	2,754	2,754	3

No.	Name of levee.	Section.			New or enlargement.	Average height—		Date of contract.	Work completed.
		Crown.	Land slope.	River slope.		Above old levee.	Above ground surface.		
	Scarsdale:					*Feet.*	*Feet.*		
1	Section 1	8	3 to 1	3 to 1	New		11.1	July 21, 1902	Oct. 23, 1902
2	Section 2	8	3 to 1	3 to 1	do		10.9	do	Sept. 29, 1902
3	Section 3	8	3 to 1	3 to 1	do		10.7	do	Sept. 4, 1902
	Savoie:								
4	Section 1	8	3 to 1	3 to 1	Enlargement.	1.5	8.6	July 22, 1902	Aug. 27, 1902
5	Section 2	8	3 to 1	3 to 1	do	1.5	7.8	July 14, 1902	Oct. 6, 1902

No.	Name of levee.	Total yardage paid for.	Price per cubic yard.	Total cost.	Distance from center of levee to river bank.			Nature of bank.
					Least.	Greatest.	Average.	
	Scarsdale:		*Cents.*		*Feet.*	*Feet.*	*Feet.*	
1	Section 1	11,917.12	15.25	$1,817.36	130	390	300	Caving.
2	Section 2	13,674.58	15.25	2,085.38	300	360	320	Do.
3	Section 3	13,683.43	15.25	2,086.73	190	330	300	Do.
	Savoie:							
4	Section 1	13,550.20	14.25	1,930.90	180	250	215	Making.
5	Section 2	13,601.31	14.25	1,938.19	130	180	155	Do.

Summary of levees built from May 1, 1902, to May 1, 1903.

	Lower Tensas district.	Atchafalaya district.	Lafourche district.	Barataria district.	Pontchartrain district.	Lake Borgne district.	Total.
Earthwork...cubic yards	505,524.31	122,852.00	....	12,285.19	611,829.95	66,426.65	1,318,918.10
Embankment..linear feet	40,397	10,383	....	2,900	51,670	7,990	113,340
Axis of river..linear feet	47,810	10,950	....	2,810	52,212	7,654	121,436

Statement of yardage of levee work constructed by the United States and others in the Fourth district, Mississippi River.

	Levee districts.					
	Lower Tensas.	Atchafalaya.	Lafourche.	Barataria.	Pontchartrain.	Lake Borgne.
Aggregate number of cubic yards of levees on the Mississippi River May 1, 1902	17,208,698	18,888,943	7,828,036	2,876,084	13,900,807	3,281,533
Added by the United States up to May 1, 1903	505,524	122,852	....	12,285	611,830	66,427
Added up to May 1, 1903, by the State and by the district levee boards	335,111	680,135	511,756	19,953	191,122	66,889
Total	18,049,333	19,691,930	8,339,792	2,908,322	14,703,759	3,414,849
Lost by abandonment from May 1, 1902, to May 1, 1903:						
By the United States	61,350	250,000	200,520	....	64,000	8,200
By the State and others	40,900	30,000	13,400	28,454	61,000	4,000
Aggregate remaining May 1, 1903	17,947,083	19,411,930	8,125,872	2,879,868	14,578,759	3,402,649

Percentage of length of existing levee system built wholly or in part by the United States.

Name of district.	1894.	1895.	1896.	1897.	1898.	1899.	1900.	1901.	1902.	1903.
	Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
Lower Tensas	52.0	52.0	59.0	63.0	66.0	72.0	71.0	71.0	72.0	73.0
Atchafalaya	16.8	48.0	47.0	68.0	65.0	67.0	68.0	69.0	68.0	67.9
Lafourche	14.4	28.8	54.0	61.0	61.0	62.0	75.0	82.0	83.0	78.0
Barataria	12.8	19.4	30.0	43.0	50.0	54.0	63.0	55.0	55.0	55.0
Pontchartrain	34.6	43.3	63.0	74.0	75.0	77.0	80.0	78.0	78.0	79.0
Lake Borgne	10.2	18.0	53.0	60.0	65.0	66.0	44.5	46.0	46.0	46.0

NOTE.—In the Lake Borgne district the percentage has decreased since 1899 on account of the limit of the district having been extended from the lower line of the Bohemia plantation to the upper line of the United States Reservation at Fort St. Philip, an increase in the length of the levee line of 124,890 linear feet.

Percentage of total length of existing levee system, Fourth district, Mississippi River improvement, built wholly or in part by the United States.

Year.	Percentage.	Year.	Percentage.
1893	13.8	1899	66.0
1894	26.2	1900	67.2
1895	36.6	1901	68.7
1896	52.0	1902	69.0
1897	63.0	1903	68.6
1898	65.0		

LOWER TENSAS LEVEE DISTRICT.

The amount expended from June 30, 1902, to June 30, 1903, is $98,411.53, distributed as follows:

Office expenses, main office	$1,917.12
Other administrative expenses	3,189.29
Construction of levees (contracts)	78,475.88
Repairs to levees	2,733.09
Surveys	531.30
Repairs to plant	198.80
Care of plant	191.81
New plant	79.40
Miscellaneous	11.90
Protection of levees	11,082.94
Total	98,411.53

Money statement.

July 1, 1902, balance unexpended		$13,046.15
June 26, 1902, amount allotted, act of June 13, 1902		110,000.00
July 1, 1902, amount available for expenditure		123,046.15
June 30, 1903, amount expended during fiscal year		98,411.53
July 1, 1903, balance unexpended		24,634.62
July 1, 1903, outstanding liabilities	$42.32	
July 1, 1903, amount covered by uncompleted contracts	11,129.29	
		11,171.61
July 1, 1903, balance available		13,463.01

ATCHAFALAYA LEVEE DISTRICT.

The amount expended from June 30, 1902, to June 30, 1903, is $30,156.24, distributed as follows:

Office expenses, main office	$1,711.60
Other administrative expenses	2,033.96
Construction of levees (contracts)	20,300.74
Repairs to levees	992.84
Surveys	110.75
Repairs to plant	180.96
Care of plant	86.17
New plant	73.50
Protection of levees	4,665.72
Total	30,156.24

Money statement.

July 1, 1902, balance unexpended		$24,090.84
June 26, 1902, amount allotted, act of June 13, 1902		40,000.00
July 1, 1902, amount available for expenditure		64,090.84
June 30, 1903, amount expended during fiscal year		30,156.24
July 1, 1903, balance unexpended		33,934.60
July 1, 1903, outstanding liabilities	$17.05	
July 1, 1903, amount covered by uncompleted contracts	30,695.00	
		30,712.05
July 1, 1903, balance available		3,222.55

LAFOURCHE LEVEE DISTRICT.

The amount expended from June 30, 1902, to June 30, 1903, is $9,687.73, distributed as follows:

Office expenses, main office	$1,141.31
Other administrative expenses	502.28
Repairs to levees	363.53
Surveys	310.10
Repairs to plant	52.50
Care of plant	43.75
New plant	129.57
Protection of levees	7,144.69
Total	9,687.73

Money statement.

July 1, 1902, balance unexpended		$7,536.37
June 26, 1902, amount allotted, act of June 13, 1902		20,000.00
July 1, 1902, amount available for expenditure		27,536.37
June 30, 1903, amount expended during fiscal year		9,687.73
July 1, 1903, balance unexpended		17,848.64
July 1, 1903, outstanding liabilities	$9.35	
July 1, 1903, amount covered by uncompleted contracts	15,121.99	
		15,131.34
July 1, 1903, balance available		2,717.30

BARATARIA LEVEE DISTRICT.

The amount expended from June 30, 1902, to June 30, 1903, is $4,514.08, distributed as follows:

Office expenses, main office	$132.49
Other administrative expenses	665.65
Construction of levees (contracts)	2,124.00
Surveys	69.05
Repairs to plant	1.50
New plant	21.73
Protection of levees	1,499.66
Total	4,514.08

Money statement.

July 1, 1902, balance unexpended		$3,080.11
June 26, 1902, amount allotted, act of June 13, 1902		10,000.00
July 1, 1902, amount available for expenditure		13,080.11
June 30, 1903, amount expended during fiscal year		4,514.08
July 1, 1903, balance unexpended		8,566.03
July 1, 1903, outstanding liabilities	$47.85	
July 1, 1903, amount covered by uncompleted contracts	3,269.58	
		3,317.43
July 1, 1903, balance available		5,248.60

PONTCHARTRAIN LEVEE DISTRICT.

The amount expended from June 30, 1902, to June 30, 1903, is $97,009.05, distributed as follows:

Office expenses, main office	$1,341.58
Other administrative expenses	3,481.21
Construction of levees (contracts)	81,720.80
Repairs to levees	1,178.22
Surveys	187.19
Repairs to plant	150.93
New plant	66.90
Protection of levees	8,882.22
Total	97,009.05

Money statement.

July 1, 1902, balance unexpended		$17,156.10
June 26, 1902, amount allotted, act of June 13, 1902		101,500.00
July 1, 1902, amount available for expenditure		118,656.10
June 30, 1903, amount expended during fiscal year		97,009.05
July 1, 1903, balance unexpended		21,647.05
July 1, 1903, outstanding liabilities	$31.95	
July 1, 1903, amount covered by uncompleted contracts	13,733.34	
		13,765.29
July 1, 1903, balance available		7,881.76

LAKE BORGNE LEVEE DISTRICT.

The amount expended from June 30, 1902, to June 30, 1903, is $13,661.10, distributed as follows:

Office expenses, main office	$289.82
Other administrative expenses	784.11
Construction of levees (contracts)	9,858.56
Repairs to levees	318.09
Repairs to plant	75.25
Care of plant	70.00
New plant	28.37
Protection of levees	2,236.90
Total	13,661.10

Money statement.

July 1, 1902, balance unexpended	$3,482.11
June 26, 1902, amount allotted, act of June 13, 1902	10,000.00
March 4, 1903, amount allotted from balance in hands of president of Mississippi River Commission	2,000.00
Amount available for expenditure	15,482.11
June 30, 1903, amount expended during fiscal year	13,661.10
July 1, 1903, balance unexpended	1,821.01
July 1, 1903, outstanding liabilities	281.31
July 1, 1903, balance available	1,539.70

The following maps and appendixes accompany and form part of this report:

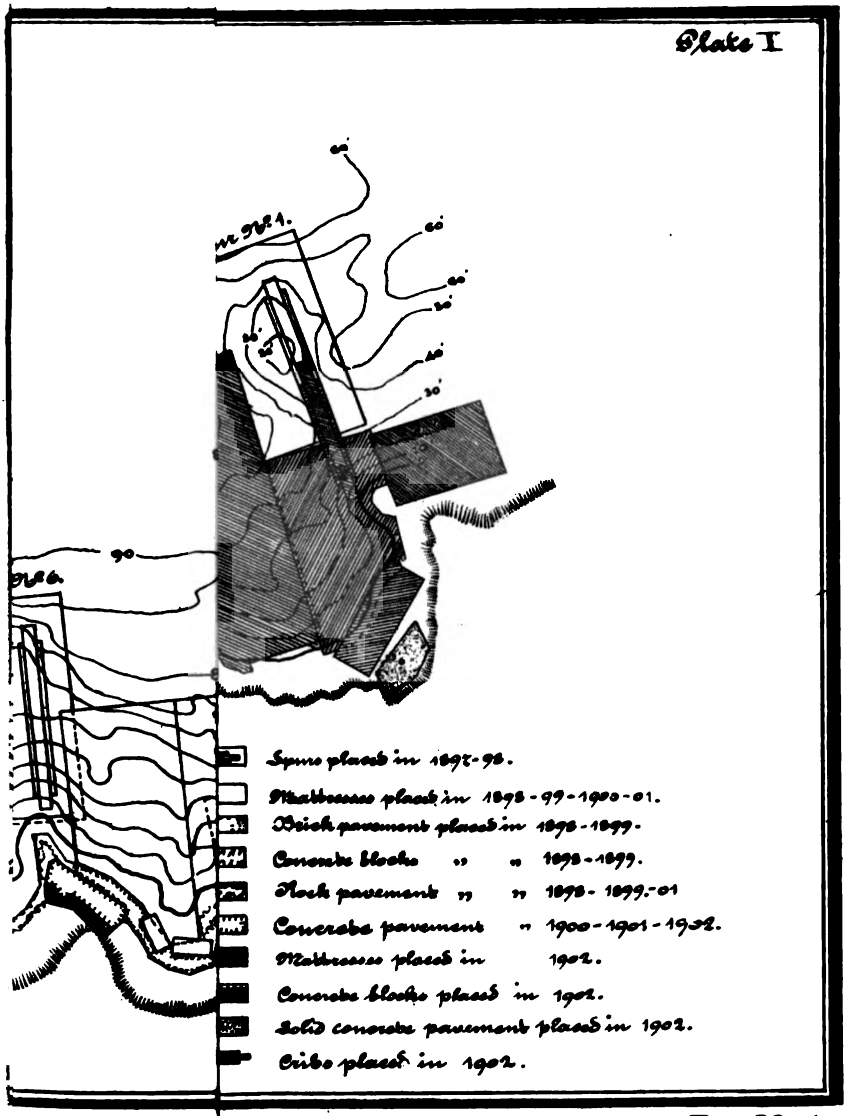
Plate I. Upper Giles Bend, revetment.
Plate II. Lower Giles Bend, revetment.
Plate III. Giles Bend, bank line.
Plate IV. Atchafalaya River, sill dams.
Plate V. New Orleans Harbor, Carrollton Bend, revetment.
Plate VI. Bondurant Chute, revetment.
Plate VII. Kempe Bend, revetment.
Plate VIII. Lower Tensas and Homochitto levee districts.
Plate IX. Atchafalya, Lafourche and Pontchartrain levee districts.
Plate X. Barataria and Lake Borgne levee districts.
Appendix 4 A. Contracts in force.
Appendix 4 B. Commercial statistics.
Appendix 4 C. Report of H. S. Douglas, assistant engineer, on revetment work.
Appendix 4 D. Report of W. E. Knobloch, superintendent, on levees.

Very respectfully, your obedient servant,

CHAS. S. BROMWELL,
Captain, Corps of Engineers.

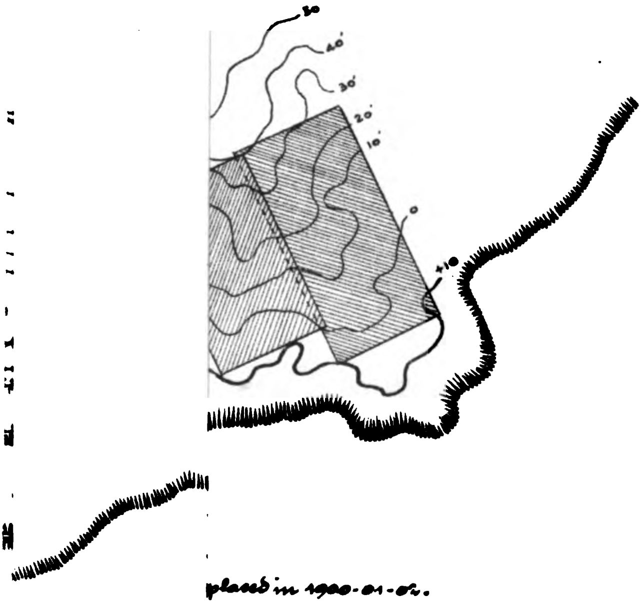
Col. O. H. ERNST,
Corps of Engineers, U. S. Army,
President Mississippi River Commission.

Plate I


ur No. 1.
60'
60'
60'
30'
40'
30'
20'
20'
90
No. 6.
Spurs placed in 1897-98.
Mattresses placed in 1898-99-1900-01.
Brick pavement placed in 1898-1899.
Concrete blocks " " 1898-1899.
Rock pavement " " 1898-1899.-01
Concrete pavement " 1900-1901-1902.
Mattresses placed in 1902.
Concrete blocks placed in 1902.
Solid concrete pavement placed in 1902.
Cribs placed in 1902.

Eng 58 1

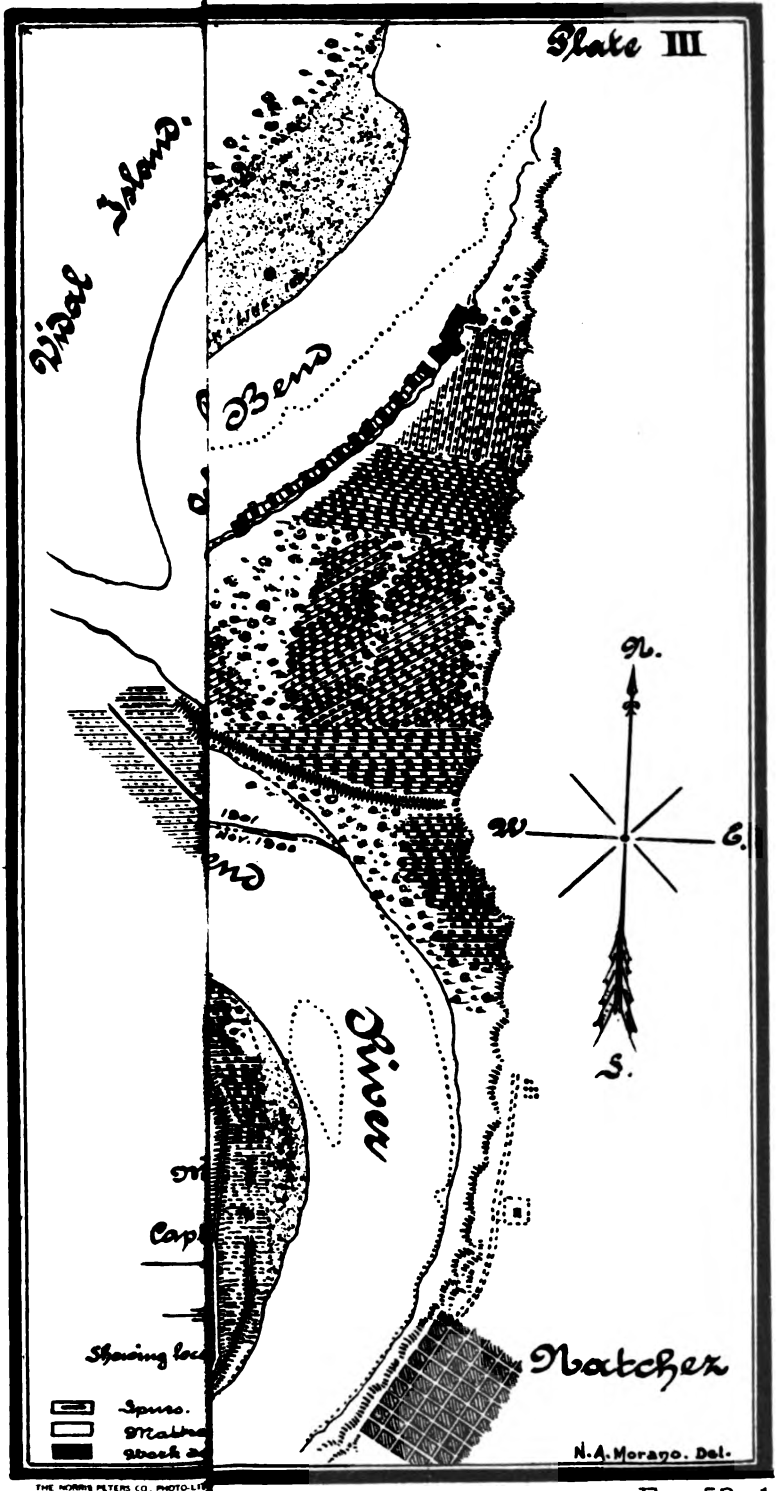
Plate II



placed in 1900-01-02.
1902
put 2"x6" placed in 1901-02.
ed Nov. 1902.

N. A. Morano, Del.

Eng 58 1



THE NORRIS PETERS CO. PHOTO-LI

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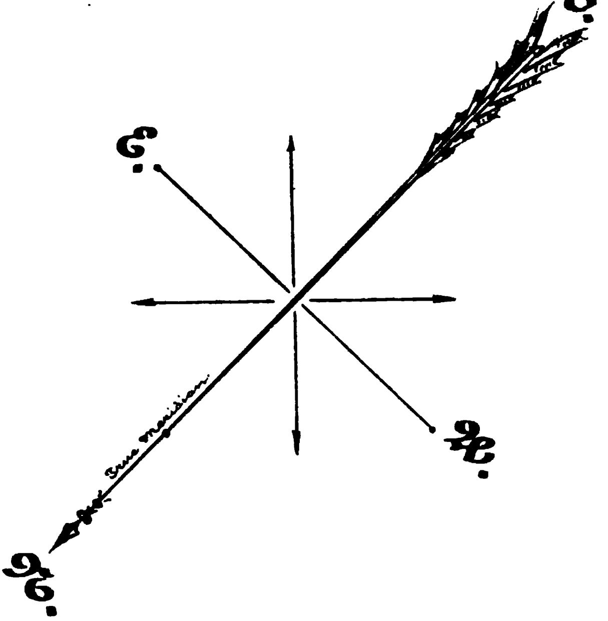
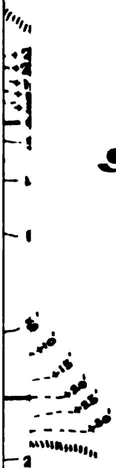
Plate IV





Improvement of
Atchafalaya & Red Rivers, La.
In charge of
as. S. Bromwell, Corps of Eng'rs, U. S. A.
tchafalaya Sill Dams.
. S. Douglas, Asst. Engr, in local charge,
Scale 1 : 2500.

50' 0 100' 200' 300' 400' 500'

are from survey of February & March 1903. after mattresses were sunk,
es of Barbee's Gauge.

Chas. S. Bromwell
Captain, Corps of Engineers, U. S. Army.

nnual Report of 1902-03.

esses placed Febry 1903.

" " Sept. 1901.

H. A. Morano. Del.

Plate VI

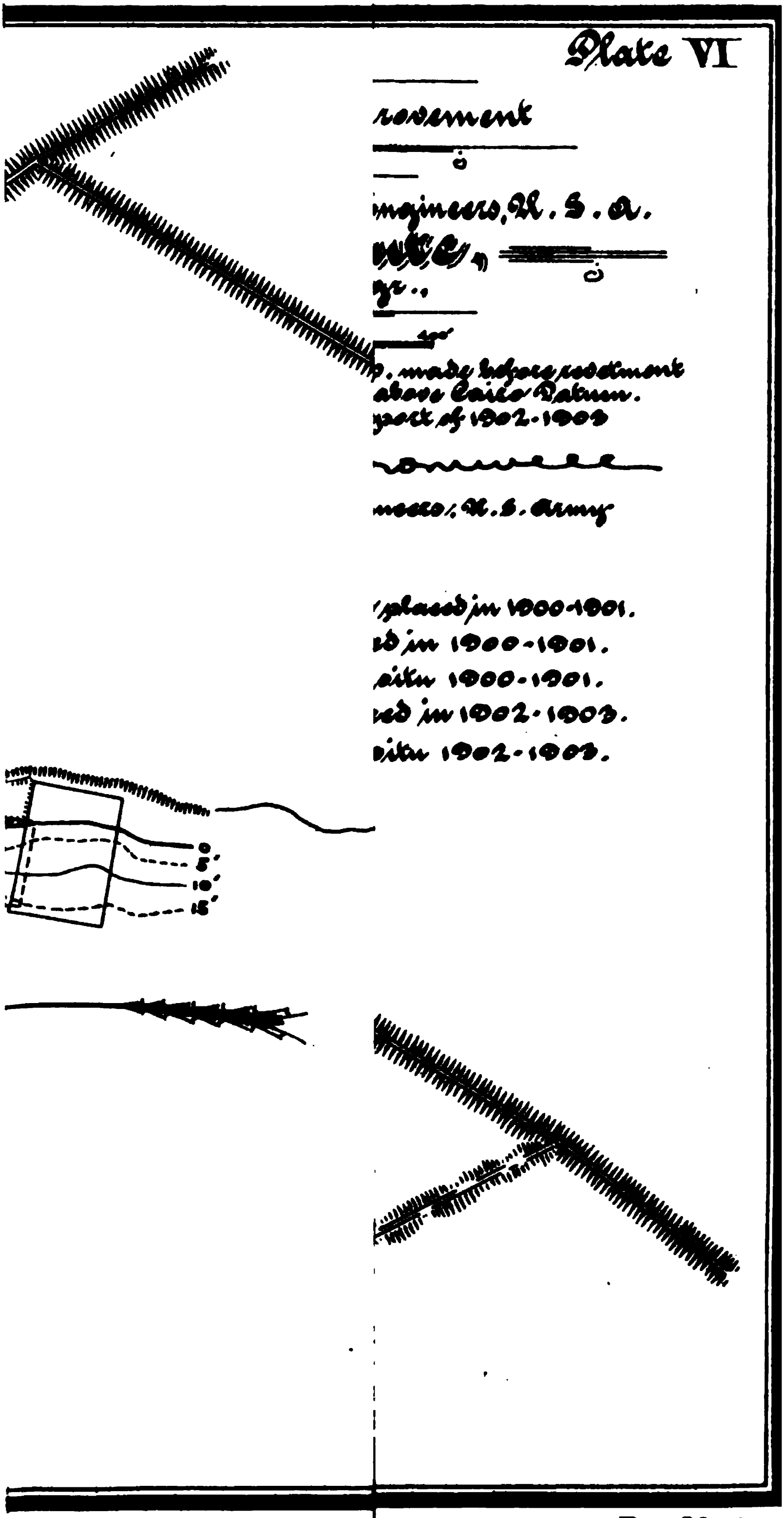


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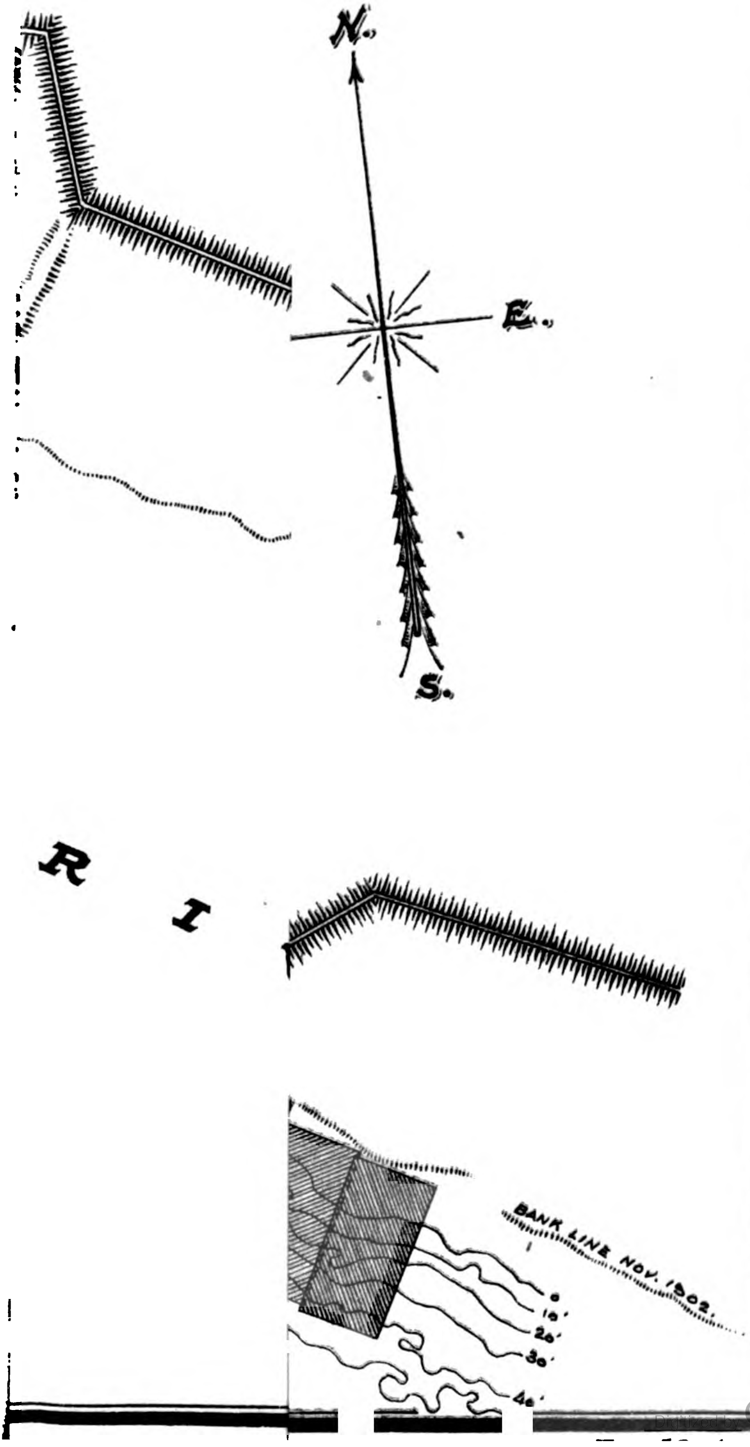
Plate VII



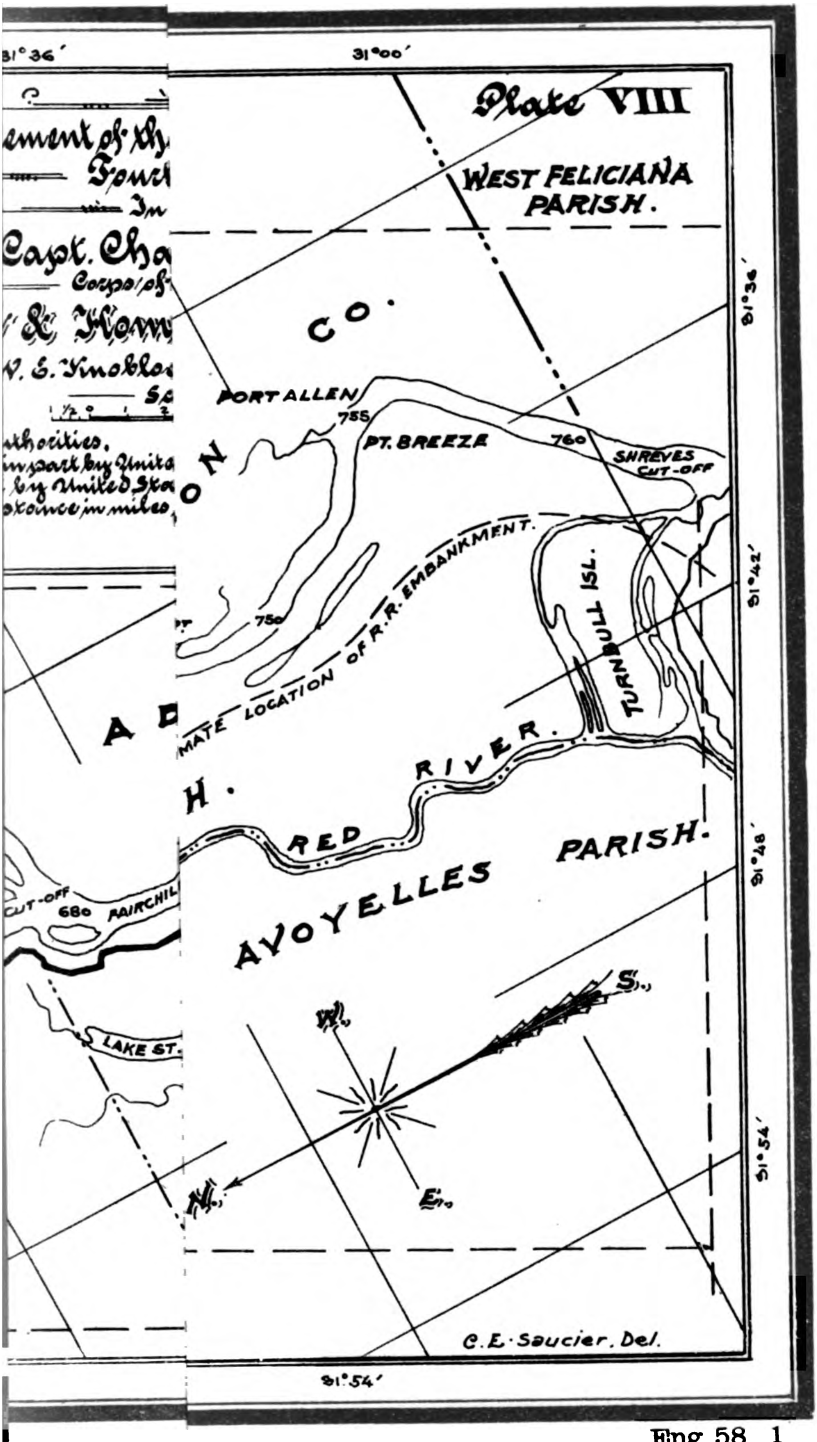


Plate VIII

Eng 58 1

30°24'
B. 1902-1903.
BAPTIST
TEXAS
LE

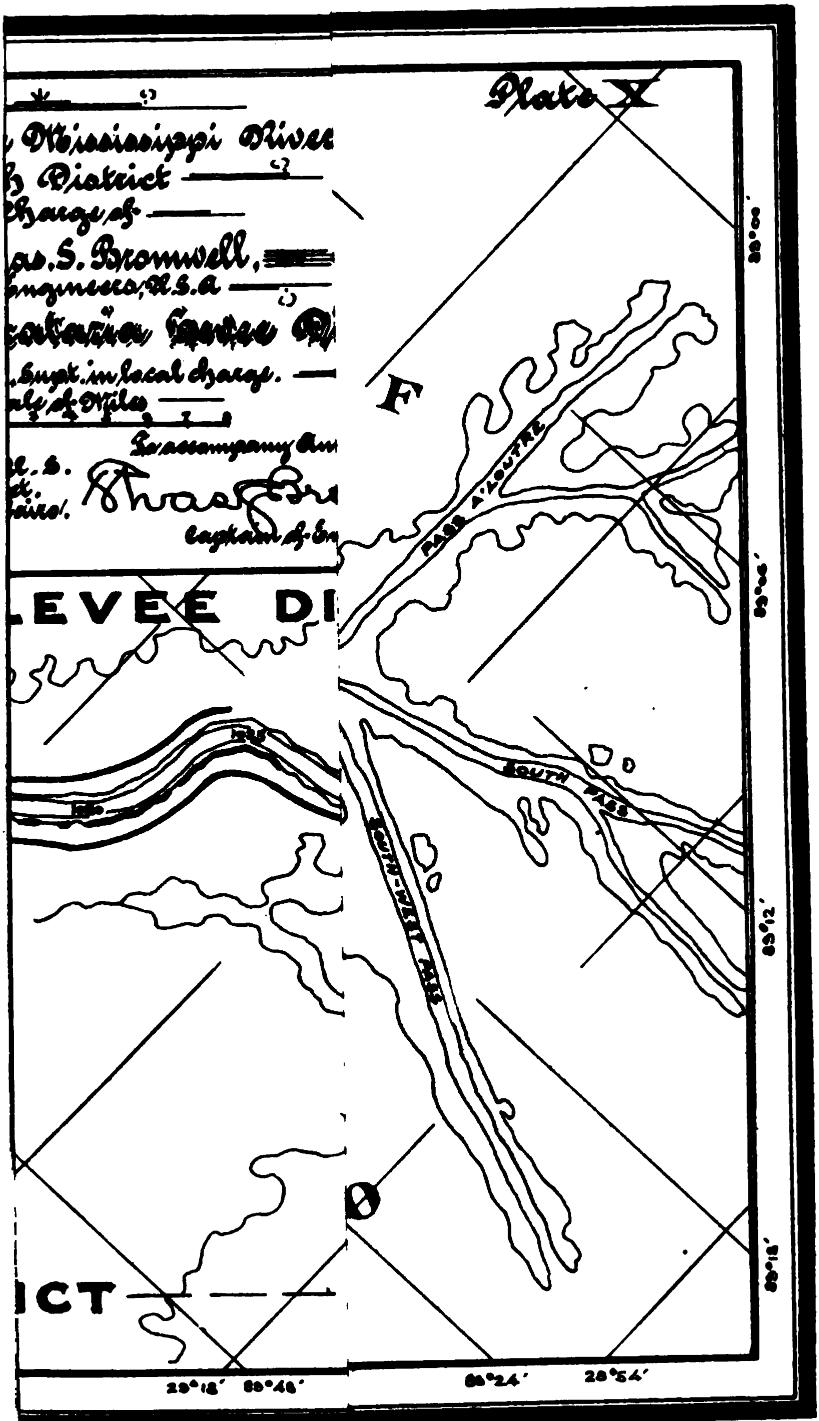


Plate X
Mississippi River
District
Charge of
as. S. Bromwell,
Engineers, U.S.A.
Supt. in local charge.
ale of Miles
To accompany An
Thos. S. Br
Captain of En
LEVEE DI
ICT
F
D
PASS A'LOUTRE
SOUTH PASS
SOUTH-WEST PASS
1825
1880
29°00'
29°06'
29°12'
29°18'
29°18'
89°48'
89°24'
28°54'

Eng 58 1

APPENDIX 4 A.

Abstract of contracts in force May 1, 1903, Fourth district, improving Mississippi River.

Nature of contract.	Contractor.	Date of approval.	Date of beginning work.	Date of expiration of contract.
Barges	J. O. Wright	Emergency	Oct. 31, 1902	Indefinite.
Earthwork (levees)	C. H. Whipple	do	Dec. 17, 1902	May 25, 1903
Do	C. D. Leeper	do	July 15, 1902	Aug. 18, 1903
Oils	Standard Oil Co	do	Feb. 10, 1903	Aug. 10, 1903
Provisions	Woodward, Wight & Co., Limited.	do	Mar. 18, 1903	June 18, 1903
Do	do	do	do	Do.
Vegetables, fruits, etc	Louis Darring	do	Mar. 20, 1903	June 20, 1903
Do	L. Mouledous	do	do	Do.
Earthwork (levees)	R. T. Clark	Apr. 11, 1903		Mar. 1, 1904

APPENDIX 4 B.

Foreign commerce, port of New Orleans.

[The statistics relating to the foreign commerce of the port of New Orleans were kindly furnished by Hon. Henry J. McCall, collector of customs.]

Vessels.	Entrances.			Clearances.		
	1900-1901.	1901-2.	1902-3.	1900-1901.	1901-2.	1902-3.
Steam	1,478	1,407	1,287	1,487	1,399	1,278
Sail	110	92	87	89	79	79
Total	1,588	1,499	1,374	1,576	1,478	1,357

Total tonnage of above.

1900-1901	5,248,725
1901-2	5,360,560
1902-3	4,792,547

There have been no new lines of transportation established or changes made in existing lines during the period covered by this report.

Exports and imports.

	1901.	1902.	1903.
EXPORTS.			
Total value of exports of foreign merchandise to foreign countries	$1,719,880.00	$2,661,271.00	$2,750,906.00
Total value of exports of domestic merchandise to foreign countries	148,077,942.00	132,793,311.00	146,663,388.00
Total value of exports of domestic merchandise to Porto Rico	882,711.00	1,919,998.00	2,473,791.00
Domestic specie exported to foreign countries	3,000.00	8,300.00	97,550.00
Total	150,683,533.00	137,382,880.00	151,985,635.00
IMPORTS.			
Total value of imports from foreign countries:			
Free	8,241,514.00	12,809,295.00	15,068,430.00
Dutiable	10,609,988.00	10,154,859.00	13,501,839.00
Transit to Mexico	1,735,302.00	2,104,950.00	1,702,084.00
Transported to interior ports	648,471.00	1,893,747.00	3,647,281.00
Specie	557,455.00	793,743.00	776,600.00
Total	21,792,730.00	27,756,594.00	34,696,234.00
Total duties collected	5,888,205.01	5,709,313.36	8,954,781.79

APPENDIX 4 C.

REPORT OF ASSISTANT ENGINEER H. S. DOUGLAS ON REVETMENT WORK.

NEW ORLEANS, LA., *May 1, 1903.*

SIR: I have the honor to submit the following report on the works under my local charge from May 1, 1902, to May 1, 1903:

BONDURANT REVETMENT.

No work was done at this locality during the season of 1901-2. The work placed in 1900-1901 was generally in good condition, but the usual pocket or cave had formed at the lower end of the revetment. This revetment covered 1,600 linear feet of bank protected with a subaqueous mattress 100 feet wide and a concrete in situ upper-bank pavement.

During the past season the following work was planned at this locality: To extend the revetment about 600 feet farther down stream and to repair the old upper-bank pavement where necessary. All this has been done.

Itinerary.—Operations were commenced on July 10, 1902, when the quarterboat *Delta* and other necessary plant was towed to the head of Bondurant Island and the construction of mattresses commenced. The high stage of the river, which varied from 27.8 to 29.6 at Vicksburg, retarded the work of mattress construction and sinking, but this was finally completed on August 2. The river being at too high a stage for upper-bank work the necessary sand and gravel was loaded on barges from Bondurant Island, towed to the revetment, and unloaded on the bank. This was necessary because at low water the Bondurant Chute is closed by dry bars at the upper and lower ends.

On October 13, the river having declined sufficiently, the force on the quarterboat *Alpha* commenced the work of grading and paving the upper bank with the usual concrete in situ pavement. Repairs to the old upper-bank revetment were also made, and the entire work completed November 21, 1902.

The usual detailed cost of the work is given here, except mattress construction, which is reported on elsewhere.

Mattress construction.—75,150 square feet (at $0.0368), $2,780.55.

Sinking.

Steamers and tugs	$312.00
Lumber, wire, wire nails, etc	18.00
522 tons concrete ballast	1,174.50
Miscellaneous	100.00
Provisions	106.00
Pay rolls	358.00
Total	2,068.50

Total square feet mattress sunk, 75,150. Cost per square foot to sink, $0.0275.

Cost of mattress in place.

Construction	$2,780.55
Sinking	2,068.50
Total	4,849.05

Cost per square foot in place, $0.0645.

Grading.—But little grading was necessary, as the bank had nearly the desired slope. The grading or dressing was done by hand. Grading, $164.45. Linear feet of bank graded, 600. Cost per linear foot, $0.274.

Paving upper bank.—The usual concrete in situ upper-bank paving was used. The cost is high, because the sand and gravel had first to be loaded on a barge, towed to the locality, unloaded on the bank, then wheeled to the mixing boards, and then the mixed concrete wheeled to the place where the pavement was to be laid. Cost of paving in detail is—

700 tons of sand and gravel	$350.00
209¾ barrels of cement	531.72
Provisions	240.00
Pay rolls	647.21
Total	1,768.93

Total square feet of bank paved, 27,245. Cost per square foot, $0.065.

In addition to this, the sum of $80.35 was expended in repairs to the old pavement.

Installation.—As the subaqueous and upper bank work had to be done at different times by different plants, the cost is large. Cost, $640.

Cost.—The total disbursements for this work from May 1, 1902, to May 1, 1903, amount to $10,157.92, distributed as follows:

Construction of mattresses	$2,780.55
Sinking of mattresses	2,068.50
Grading upper bank	164.45
Paving upper bank	1,768.93
Installation	640.00
Surveys	21.32
Miscellaneous	31.54
Repairs to plant	415.96
Care of plant	330.46
New plant	488.13
Contingencies and administration	1,448.08
Total gross cost	10,157.92
Deduct last four items	2,682.63
Total net cost	7,475.29

Summary.

Lineal feet of bank protected	600
Lineal feet of bank mattressed	600
Lineal feet of bank graded	600
Square feet of bank paved	27,245

The total amount expended for all purposes is $10,157.92, which divided by 600 gives the total cost per lineal foot of protected bank as $16.93. Deducting "repairs to plant, care of plant, new plant and contingencies, and administration," the net cost per lineal foot of protected bank is found to be $12.46.

Conclusion.—At the close of this report the river is near extreme flood height, but, so far as is known, the work is in good condition and accomplishing the purpose for which it was designed.

KEMPE BEND REVETMENT.

At date of last report the bank had been mattressed over a distance of 4,318 feet, and graded and paved for a length of 3,840 feet. The work had been inspected and surveyed and was in good condition. During the season 1901-2 practically no work was done except minor repairs.

The following work was projected during the past season: To extend the revetment about 600 feet downstream to cover the usual pocket that had formed at the lower end; to extend the existing revetment about 900 feet at the upper end, and to place about 900 feet of revetment at a point farther up the bend to protect a salient angle in the levee; to make minor necessary repairs to existing work. All of this has been done.

Itinerary.—Operations were commenced August 15, when the quarterboat *Delta* was moved to Ships Bayou bar and the construction of mattresses commenced. This force was augmented by the quarterboat *Gamma* on August 18, and by the quarterboat *New Orleans* on September 15. On this last date the *Gamma* was moved to Kempe Bend to sink mattresses. Sinking, grading, and paving was continued in Kempe Bend until October 22, when sinking was suspended after completing all but the isolated 900 feet of revetment in the upper part of the bend to protect a salient angle in the levee. On December 14 the *Gamma* was returned to Kempe Bend and completed the sinking on this 900 feet, the last mattress being sunk on December 27.

The detailed cost of mattress construction is given elsewhere. That of the other items is analyzed, as usual.

Mattress construction.—762,105 square feet, at $0.037, $28,197.88.

Towing.—The mattresses used at Kempe Bend were built at Shipps Bayou Bar and at Brooks Landing Bar, about 33 miles above the revetment, and the cost of towing was:

Tug *Humphreys*, sixteen days, at $26	$416
Tug *Comstock*, ten days, at $22	220
Tug *Tilda*, five days, at $20	100

Tug *Gillespie*, four days, at $27	$10
Steamer *Newton*, six days, at $32	1
The Ram, four days, at $33	1
Total	1,16

Square feet of mattress towed, 762,105. Cost per square foot for towing, $0.00153.

Sinking.—Contrary to past experience in this bend, the work of sinking progressed almost without incident. But one accident occurred by which a small portion of mattress was lost.

Steamers and tugs	$2,610.
Lumber, wire, wire nails, etc	350.
5,856 tons of concrete ballast	10,306.
Provisions	1,250.
Miscellaneous	350.
Pay rolls	4,038.
Total	18,905.4

Square feet of mattress sunk, 744,105. Cost per square foot to sink, $0.02541.

Cost of mattress in place.

Construction of mattress	$28,197.
Towing of mattress	1,168.
Sinking of mattress	18,905.4
Total	48,271.

Cost per square foot in place, $0.06487.

Grading upper bank.—All grading was done with Hydraulic Grader No. 5, operating two jets most of the time. It is unusual on heavily timbered bank for the cost to be low. Total cost of hydraulic grading, including services of tugs and incidentals, $3,470.84. Lineal feet of bank graded, 2,500. Cost per lineal foot of graded bank, $1.388.

Paving upper bank.—The usual concrete in situ pavement described in previous reports was used. The embedded wire mesh and the lumber dividing it into squares was omitted.

485 barrels of cement	$1,229.48
1,200 tons of sand and gravel	480.00
Services of tugs	284.00
Provisions	532.76
Pay rolls	1,729.19
Total	4,255.43

Square feet of bank paved, 70,637. Cost per square foot, $0.0602.

In addition to this there was expended on repairs to old work the sum of $396.41.

Timber felling.—To prevent trees caving into the river and forming obstructions to future work, and to clear off the bank for hydraulic grading, about 10 acres of timber were felled, logged, and cleared up, the cost being—

Provisions	$168.10
Pay rolls	404.02
Total	572.12

Acres cleared, about 10. Cost per acre to clear, $57.21.

Installation.—This item covers the cost of moving the plant from place to place and getting in shape for actual construction. Cost, $2,290.43.

Surveys.—The usual survey work incidental to placing the mattresses and platting a field chart was done. A complete hydrographic survey of the work in place, and of the proposed extension, was made in August, September, and October. In addition five accurate cross sections of the river were located and sounded at the head of Kempe Bend, locating the channel as it enters the head of the bend and first commences to encroach on the concave bank. The total cost of the survey work was $792.76.

Cost.—The total disbursements on account of this work from May 1, 1902, to May 1, 1903, were $88,133.09, distributed as follows:

Construction of mattresses	$28,197.88
Towing of mattresses	1,168.00
Sinking of mattresses	18,905.47
Grading upper bank	3,470.34
Paving upper bank	4,255.43
Repairs to old pavement	396,41
Clearing upper bank for grading	572.12
Installation	2,290.43
Surveys	792.76
Manufacture of concrete ballast	11,658.89
Miscellaneous	71.93
Repairs to plant	2,502.76
Care of plant	5,300.86
New plant	1,141.84
Contingencies and administration	7,407.97
Total	88,133.09
Deduct value of material on hand available for future construction	4,014.52
Total gross cost	84,118.57
Deduct "repairs, care of, and new plant," and administration and contingencies	16.353.43
Total net cost	67,765.14

Summary.

The total work done on Kempe Bend revetment during the past season consists of—

Lineal feet of bank protected	2,725
Lineal feet of bank mattressed	2,725
Lineal feet of bank graded	2,500
Square feet of bank paved	70,637

The total gross cost of the season's work is $84,118.57. Gross cost per lineal foot of bank protected, $30.87. The total amount expended, less "repairs to plant," "care of plant," "new plant," and "contingencies and administration," is $67,765.14. Net cost per lineal foot of bank protected, $24.87.

Conclusion.—So far as can be judged from a careful inspection, observing currents, etc., during high water, the work is in good condition and serving well the purpose for which it was designed. The total length of protected bank in Kempe Bend is now 6,775 feet.

IMPROVING HARBORS AT NATCHEZ AND VIDALIA, MISSISSIPPI AND LOUISIANA (GILES BEND REVETMENT).

At date of last report there was in place 13,040 lineal feet of revetment of various kinds measured along the shore line. The work was generally in good condition.

The proposed work of the last season was as follows: Prolong the Lower Giles Bend revetment about 1,000 feet upstream. Mattress the intervals between spurs 1 and 2, and 2 and 3, maintaining the connection between the spurs and shore of the Upper Giles Bend revetment, and to make minor repairs to existing work, all of which and more has been done.

Itinerary.—Operations were commenced July 29, when Hydraulic Grader No. 5 commenced grading upper bank. Mattress construction was begun at Shipps Bayou Bar on September 23 by the quarterboats *New Orleans* and *Delta.* When the willows at this locality were exhausted the plant was moved to the bar at the lower end of Kempe Bend, and mattress construction continued there until November 18. The quarterboat *Gamma* was moved from Kempe to Giles Bend on October 22 to sink mattresses, pave upper bank, etc. All this work was completed on December 13, 1902.

Mattress construction.—For the sake of brevity this important portion of the various works is here consolidated. The character of the mattress work is practically identical, no matter whether they are to be used at Kempe Bend, New Orleans Harbor, or any other work. During the past season mattress construction was prosecuted at Bondurant Island, at Shipps Bayou Bar, at Brooks Landing Bar, on the bar at the upper and at the lower end of Kempe Towhead, and at Point Breeze Bar, six different localities entailing six separate installations. The numerous changes were occasioned by various causes—consumption of all available willow brush, abrupt rises in the river overflowing low bars, etc. All three of the large quarterboats were engaged on the work at various times, as the exigencies of mattress construction required. A total of 2,026,330 square feet (46½ acres) of mattress were built, of which 93,000 square feet ($4\frac{6}{10}$ per cent) were lost from various causes. About 20,263 cords of willow brush were used, cut from 540 acres of land. Details of material and cost are as follows:

Willow brush.

Teams hauling	$9,935.11
Cutting, loading, etc	6,980.57
Privilege of land	220.89
Total	17,136.57

Total cords of willow brush, 20,263. Cost per cord delivered at ways, $0.845.

Construction.

74,112 feet B. M. miscellaneous lumber	$874.52
765,989 feet B. M. 2 by 4 inch lumber	10,029.46
393,643 feet B. M. 3 by 6 inch lumber	4,644.98
36,067 pounds 9 inch steel wire nails	815.11
71,326 pounds 6 inch steel wire nails	1,611.96
10,851 pounds 4 inch steel wire nails	244.23
14,352 pounds No. 10 galvanized wire	382.32
20,263 cords willow brush	17,136.57
Tree nails	507.00
Steamers and tugs	4,200.00
Miscellaneous	113.10
Provisions	9,088.65
Pay rolls	25,422.48
Total	75,070.38

Total square feet of mattress built, 2,026,330. Cost per square foot, $0.037.

Of this, 836,575 square feet were used in Giles Bend, valued at, $30,953.27.

Towing.—The mattresses for Giles Bend were towed from 20 to 60 miles down stream.

Steamer *Newton*, eight days at $32	$256.00
The Ram, four days at $33	132.00
Tug *Humphreys*, fourteen days at $26	364.00
Tug *Comstock*, eight days at $22	176.00
Total	928.00

Total square feet mattress towed, 836,575. Cost per square foot for towing $0.00111.

Sinking.—No incident worthy of note occurred. The conditions in this bend at low water are very favorable for bank protection work.

Steamers and tugs	$1,077.00
Lumber, wire, wire nails, etc	326.21
5,790 tons of concrete ballast	13,648.62
Miscellaneous	340.00
Provisions	1,120.22
Pay rolls	3,473.71
Total	19,985.76

Square feet of mattress sunk, 836,575. Cost per square foot to sink, $0.0239.

Cost of mattress in place.

Construction of mattress	$30,953.27
Towing of mattress	928.00
Sinking of mattress	19,985.76
Total	51,867.03

Total cost per square foot, $0.062.

In "maintaining the connection between the spurs and shore" it was necessary to build some cribs, sink the same, and regrade and pave. The total cost of this was $2,070.55.

Grading upper bank.—All grading was done with hydraulic grader No. 5, operating most of the time with one jet.

Total cost of hydraulic grading, including services of tug and incidentals, $3,022.31. Lineal feet of bank graded, 1,700. Cost per lineal foot of graded bank, $1.78.

Paving upper bank.—The usual concrete-in-situ pavement was used without the embedded wire mesh or the use of lumber to form squares.

620 barrels of cement	$1,571.70
1,500 tons of sand and gravel	600.00
Services of tugs	202.00
Miscellaneous	200.00
Provisions	425.60
Pay rolls	1,409.97
Total	4,409.27

Total square feet of bank paved, 89,752. Cost per square foot, $0.0491.

The sum of $428.37, in addition to the above, was expended in repairs to existing pavement.

Timber felling.—Felling timber, logging and removing same, and clearing up the bank for grading cost $223.20, divided as follows:

Provisions	$53.20
Pay rolls	170.00
Total	223.20

Installation.—Cost, $1,858.

Surveys.—In addition to the usual routine survey work for the placing and locating of mattresses and platting of the field chart a careful hydrographic survey of the work in place and to be placed was made. This survey was made in October, November, and December. The total cost of survey work was $553.43.

High-water protection.—In March, 1903, it became evident that an extraordinary flood was to occur in the Mississippi. The spur levee on Cowpen Neck has always required attention during floods. Accordingly a small force on the quarterboat *Alpha* was stationed at the levee during March and April, 1903. Considerable work for the high water maintenance of the levee was done, about 3,000 sacks being used to repair wave wash, sloughs, etc. The cost of this work was $754.58.

Cost.—The total cost of this work from May 1, 1902, to May 1, 1903, was $73,140.70, distributed as follows:

Construction of mattresses and cribs	$32,155.27
Towing of mattresses and cribs	928.00
Sinking of mattresses and cribs	20,854.31
Grading upper bank	3,022.21
Paving upper bank	4,409.27
Repairs to old pavement	428.37
Clearing upper bank for grading	223.20
Installation	1,858.00
Surveys	553.43
Miscellaneous	187.89
High-water protection, spur levee	754.58
Repairs to plant	1,509.45
Care of plant	1,433.31

New plant	$1,221.72
Contingencies and administration	3,601.59
Total gross cost	73,140.6
Deduct last five items	8,520.65
Total net cost	64,619.95

NOTE.—Three hundred and sixty thousand square feet of mattress, valued at $13,320, that were built for and paid for from this allotment for New Orleans Harbor, were sunk in Giles Bend revetment because of an emergency requiring the immediate return of the sinking plant to Kempe Bend instead of proceeding to New Orleans.

Summary.

The following work has been done in Giles Bend during the past season:

Square feet of bank paved	89,752
Lineal feet of bank protected	3,20
Lineal feet of bank mattressed	3,20
Lineal feet of bank graded	1,700

All measured along the shore line.

It must not be forgotten that the approved project for work on the Upper Giles Bend revetment provides that the upper bank shall only be paved where it is brought to about the desired slope by the action of the river. Therefore the cost is low because no upper bank pavement was done at the new work in this locality except such as was necessary to maintain the integrity of the spurs. Bearing this in mind the unit of cost of the past season's work is given. Gross cost per lineal foot, $22.86; net cost per lineal foot, $20.19.

Conclusion.—The total length of bank protected in Giles Bend is now 16,24 lineal feet, measured along the shore line. So far as is known at the present stage of the river the entire work is in good condition.

IMPROVING ATCHAFALAYA AND RED RIVERS, LOUISIANA.

At date of last report Sill Dam No. 1 had been widened to 560 feet by an apron mattress on the upper and lower sides and Sill Dam No. 3 widened to 430 feet by an apron mattress on the lower side. The work was in good condition.

Operations planned during the last season was to further widen the foundation mattress of Sill Dam No. 3 and to maintain the channel through Lower Old River. This has been done.

Itinerary.—Work was commenced on January 22, when the *Gamma* was moved to Point Breeze Bar and began the construction of mattresses. On January 30 the *Delta* arrived on the work, and on February 2 the *Gamma*, with necessary plant, was moved to near Simmsport on the Atchafalaya to sink mattresses at Sill Dam No. 3. The work projected was completed on February 11, and the sinking plant moved to New Orleans Harbor.

Mattress construction.—One hundred and twenty thousand square feet of mattress (at $0.037), $4,440.

Towing.—On account of the rise in the Red and Ouachita rivers the current in Lower Old River was running toward the Mississippi. This made the towing of the mattresses from the Mississippi River to Barbres Landing at the head of the Atchafalaya River, difficult and expensive:

Tug *Gillespie*, five days, at $27	$135.0
Tug *Humphreys*, five days, at $26	130.0
Tug *Comstook*, seven days, at $22	154.0
Tug *Tilda*, four days, at $20	80.0
Total	499.0

Square feet of mattress towed, 120,000. Cost per square foot for towing, $0.00416

Sinking.—The apron mattress on the upstream side of Sill Dam No. 3 was sunk successfully and without incident.

Steamers and tugs	$216.0
Lumber, wire, wire nails, etc	61.9
974 tons of concrete ballast	1,709.0

Provisions	$166.00
Pay rolls	556.09
Total	2,709.01

Square feet of mattress sunk, 120,000. Cost per square foot to sink, $0.0226.

Cost of mattress in place.

Construction of mattress	$4,440.00
Towing of mattress	499.00
Sinking of mattress	2,709.01
Total	7,648.01

Cost per square foot in place, $0.0621.

Installation.—Cost, $118.

Surveys.—The usual survey work to determine the desired position of the mattress and its actual position after being sunk was done. In addition a careful hydrographic survey was made of the Atchafalaya from above Sill Dam No. 1 to below Sill Dam No. 3. The cost of survey work was $672.28.

Cost.—The total amount expended for work on the sill dams is $10,102.09, distributed as follows:

Construction of mattress	$4,440.00
Towing of mattress	499.00
Sinking of mattress	2,709.01
Installation	118.00
Surveys	672.28
Miscellaneous	65.00
Repairs to plant	97.31
Care of plant	274.27
New plant	117.30
Contingencies and administration	1,109.92
Gross cost of work on sill dams	10,102.09
Deduct last four items	1,598.80
Net cost of work on sill dams	8,503.29

Summary.

The work of the season was confined to the placing of 120,000 square feet of mattress on the up stream side of Sill Dam No. 3.

MAINTENANCE OF CHANNEL BETWEEN THE MISSISSIPPI AND RED AND ATCHAFALAYA RIVERS.

During the past season the rivers have remained at too high a stage to require any work on the channel through Lower Old River. An amount ($490.79) has been expended for the care and preservation of the hydraulic dredge *The Ram*, belonging to this work.

Conclusion.—The figures given under the heading "Cost of mattress in place," $7,648.01, or $0.0621 per square foot, should be used for comparative purposes. On this character of work the lineal foot of bank protected is not applicable as a unit of cost. At the present high stage of the river nothing can be known definitely as to the condition of the work. It is believed to be good.

NEW ORLEANS HARBOR.

The work of previous years was generally in good condition. This work has been fully described in the different annual reports dating back to 1884.

Operations planned during the past season consisted of mattressing the lower bank above Southport for a length of 1,800 feet with mattresses 250 feet wide, with their inshore edges along the 60-foot contour, and extending the existing revetment for a length of about 4,750 feet below Southport with similarly sized and placed mattresses. But a small portion of this work has been done, on account of the late date when the work of sinking was commenced and the early and sudden rise of the river.

Itinerary.—The most of the mattresses actually used in New Orleans Harb were built at Point Breeze Bar, where work was commenced on January 22, 19 Other mattresses intended for this work were previously built at Kempe Towhea but were used in Giles Bend. The reason for this was that when the work ori inally contemplated in Giles Bend was nearing completion an emergency develope at Kempe Bend above requiring that the plant be returned to that place. It i impracticable to tow mattresses upstream, and to avoid their loss by silting u and sinking at their moorings, these mattresses were used to extend the Gil Bend revetment beyond the limit set for the season's work. This, together wi other revetment work at Bondurant, Kempe, and the Atchafalaya sill dams, ha consumed the best part of the working season, and on February 11 it becam evident that the rapidly rising river would either greatly curtail the amount work that could be done or possibly prevent it altogether. Mattress constructi was therefore suspended on February 12 for the season, and such mattresses a had been built, together with the necessary plant, towed to New Orleans, an preparations to sink at Southport made.

The plant was placed in position on February 19, by which time the river ha risen to within 5 feet of the highest recorded flood. The batture, or foreshor between the levee and the river bank was all submerged, and great difficulty wa encountered in finding moorings for the plant. A piece of abandoned old leve was all that could be found and in it "dead men," to hold the wire cables, wer placed. On February 21 the first mattress was successfully sunk. On Februar 25 an attempt to sink another mattress was made, but it resulted disastrousl The "dead men," to which the wire cables holding the plant and mattress position were fastened, pulled through the old levee, and when the mattress finall landed on the bottom its position was indeterminate but known to be far fro that desired. It was evident that if the mattresses were to be sunk at all secur moorings would have to be established. A pile driver was hired and five lar clusters of piles driven for the principal moorings. Several small clusters f auxiliary moorings, fenders for plant to rest against, etc., were also driven. A of this of course consumed time, and it was not until March 7 that the plant coul again be swung into position. By this time the river was only 2 feet belo extreme flood height. On March 10 another mattress was sunk successfully, b in two sections. From the experience gained in this last sinking it was evide that it was impracticable at high water to place the mattresses with their insho edge along the 60-foot contour. The attempt was therefore abandoned, and t remaining mats sunk farther inshore. About this time there was an urge demand for the entire plant to be used on the high-water protection of leve The incongruity of carrying on bank revetment, essentially a low-water job, a stage of the river when the plant was required for the protection of the levees apparent. The last available mattress was sunk on March 16, and further wo for the season abandoned. On this last date the river lacked but a few tenths the highest known flood. A raft of logs broke loose at night and parted the moo ings of two sections of mattress. Before the alarm could be given the mattress had floated below the plant and were abandoned, as at the then stage of the riv it was impracticable to tow them upstream.

Mattress construction.—One hundred and fifty-seven thousand five hundr square feet, $5,827.50.

Towing.—The mattresses were towed from Point Breeze Bar to Southport (Ne Orleans Harbor), a distance of 210 miles, without accident.

Tug *Gillespie*, seven days, at $27	$189.0
Tug *Humphreys*, seven days, at $26	182.0
Total	371.

Square feet of mattress towed 210 miles, 157,500. Cost per square foot for tow ing, $0.00236.

Sinking.—The disasters attending sinking and the reasons therefor are set fort in the itinerary.

Steamers and tugs	$651.
Lumber, wire, wire nails, etc	177.
1,184 tons of rock	1,184.
Driving pile moorings	347.
Provisions	518.
Pay rolls	1,931.
Total	4,809.

Square feet of mattress sunk, 157,500. Cost per square feet to sink, $0.0305.

Cost of mattress in place.

Construction	$5,827.50
Towing	371.00
Sinking	4,809.16
Total	11,007.66

Cost per square foot in place, $0.0700.

Installation.—Cost, $371.19.

Surveys.—The usual survey work to plan the position of the mattresses and to locate them after being sunk was done. A complete hydrographic survey over the work of previous years was not entirely completed on account of high water. The cost of survey work was $683.92.

Cost.—The total disbursements from May 1, 1902, to May 1, 1903, from the New Orleans Harbor allotment, were $40,676.36, distributed as follows:

Revetment work New Orleans Harbor	$11,007.66
Surveys	683.92
Repairs to plant	1,255.96
Care of plant	2,728.79
New plant	2,325.54
Contingencies and administration	4,463.16
Mattresses built for New Orleans Harbor and sunk in Giles Bend	13,320.00
Construction material on hand, about	4,891.33
Total	40,676.36
Deduct mattresses sunk in Giles Bend	13,320.00
	27,356.36
Deduct material on hand	4,891.33
Gross cost season's revetment work in New Orleans Harbor	22,465.03
Deduct "repairs to plant," "care of plant," and "contingencies and administration"	10,773.45
Net cost of revetment work in New Orleans Harbor	11,691.58

Summary.

One hundred and fifty-seven thousand five hundred square feet of mattress were sunk, the gross and net cost being, respectively, $0.142 and $0.074 per square foot in place. The explanation of the excessive cost will be found in the itinerary. It is fair, however, to consider that a certain amount of the expense on account of plant and administration and contingencies should be charged against the New Orleans Harbor mattresses sunk in Giles Bend, which would considerably reduce the gross cost as here given.

Conclusion.—Mattresses have been sunk at a higher stage of the river than was even contemplated with existing plant and methods. The results have been very unsatisfactory, except that valuable experience has been gained. No caving of the revetted bank in New Orleans Harbor has occurred since last report, and it is therefore assumed that the present condition of the work is good.

MANUFACTURE OF CONCRETE BALLAST.

Operations were carried on during the past season at Kempe Towhead and at Bondurant Island. The work was essentially similar to that of last season, as described in the report for 1901–2. It was stated in that report that improvements could be made in details that would lessen the cost. A brief description of these improvements is here given:

On a covered barge was installed a large boiler, the necessary engines, pumps, and the concrete mixer. The necessary irons were purchased, and a 5-ton, stiff-leg derrick erected on one side of what we will term the "mixer barge." The mixer itself was installed so as to discharge on the opposite side, and a suitable hopper or chute erected to conduct the raw materials to the mixer. To convey the mixed concrete from the mixer to the molds set up on a barge alongside the mixer barge a specially designed "conveyor" was planned and built. The novel feature of this conveyor was that it could be moved in any direction without interfering or stopping its action as a conveyor. It was driven by the same engines as the mixer itself, and the speed of the conveyor belt so adjusted by suitable gearing as to carry off the product of the mixer without being overloaded. The derrick was operated by independent engines. Four large steel buckets were obtained and their capacity so regulated by adjustable false bottoms that a sack of cement added to a bucket full of sand and gravel would give the approved proportions—16 to 1, 14 to 1, or whatever was desired. It was the intention to load barges with dredged sand and gravel, using the hydraulic dredge *The Ram* for this purpose. These barges were to be placed on the derrick side of the mixer barge and an empty barge with the molds set up placed on the conveyor side. This would have dispensed with wheeling the raw and manufactured material altogether. It was never done because *The Ram* could not be spared from other work, and when she could be her dredging machinery broke down after a short trial. In practice the work was done as follows: The mixer barge was moored close to the gravel bar and suitable platforms and runs arranged so that the sand and gravel could be wheeled to the buckets. The necessary cement was fed into the buckets as they were being loaded. They were then hoisted up by the derrick and dumped into the hopper of the mixer, thence through the mixer to the conveyor, which dropped the mixed concrete into the molds. The entire apparatus worked in the most satisfactory manner, and while improvements may be made they are those of detail and not of principal.

Itinerary.—The plant arrived at Kempe Towhead on August 18, and commenced the manufacture of concrete on August 28. As it was desired to use th personnel to grade and pave the upper bank at Bondurant revetment, the plan was moved to Bondurant Island on October 10, and the manufacture continue at such times as the force could not be used on the revetment. On November the plant was returned to Kempe Towhead and the industry continued unt February 5, 1903, when, after making a total of 10,683 tons of concrete ballas work was suspended for the season.

Cost.—While great improvements have been made, both in method and detai the manufacture of concrete ballast for sinking mattresses is still an experiment industry. The question of cost is therefore the most important, if not th governing factor.

From May 1, 1902, to May 1, 1903, there is charged to the manufacture of concrete ballast the sum of $24,879.76. To this should be added the value of ceme on hand at the commencement of the season's work. From the total thus obtain should be deducted the value of the cement now on hand, value of cement us for upper-bank pavement, and the cost of plant now on hand. These items ar shown in the statement below.

Total expended May 1, 1902, to May 1, 1903	$24,879.7
Add cement on hand May 1, 1902	1,663.
	26,543.5
Deduct cement on hand May 1, 1903	765.5
	25,777.
Deduct cement used for upper-bank pavement	3,332.
	22,445.0
Deduct plant purchased and on hand	2,132.5
Total expended manufacture of concrete ballast	20,312.5

The total number of tons of concrete made during the season was 10,683. Divi ing this into $20,312.53 gives $1.90 as the absolute total cost per ton. There ca be but little question as to the correctness of this figure. If it is claimed that th cost of plant should not be deducted, then why not include the cost of boat barges, etc., in ordinary bank revetment work? The rule should be general.

On a selected day the field cost per ton was—

Supervision, subsistence, care of plant, services of *Ruby*, coal, oil, sand, and gravel making concrete, per ton	$0.3
Value of cement used, per ton	.78
Total cost per ton on selected day	1.16

The average field cost per ton of manufactured concrete is $1.5477, made up as follows:

Cement	$0.8361
Supervision	.0445
Subsistence	.2183
Crew of *Ruby*	.0379
Coal, oil, etc	.0430
Operating mixer	.1383
Feeding cement to mixer	.0238
Wheeling sand and gravel	.1093
Tamping concrete in molds	.0328
Moving and setting up molds	.0637
Average field cost per ton	1.5477

Summary.

Total tons (2,000 pounds) concrete ballast made	10,683
Total amount expended manufacture of concrete ballast	$20,312.53
Total cost per ton	$1.90
Average field cost per ton	$1.548
Least field cost per ton	$1.169

Conclusion.—The showing made is not unfavorable, but in breaking up the blocks to a convenient size for handling and loading on the mattress there is a percentage of loss. It has been impracticable to obtain this percentage accurately, although numerous attempts have been made. The blocks are broken up with a sledge and some portion of them is reduced to the original sand and gravel, which, of course, is not effective ballast on the mattress. Opinions differ, but it is thought that about 10 per cent of the concrete, as measured on the barge, is lost in breaking up.

PLANT.

At date of last report the plant consisted of 47 large pieces. During the year two steel hull tugboats have been purchased and named the *General Gillespie* and *General Abbot*. The following is a description of these boats:

General Gillespie.—Built in 1898 by Neafie & Levy; length, 92 feet; beam molded, 19 feet; draft, 9 feet; hull of steel, three-eighths inch to seven-sixteenths inch thick; cabin of steel; boiler, Scotch marine, 10 feet 3 inches by 11 feet 11 inches, allowed 125 pounds steam pressure; engines fore and aft compound, 15-inch, and 26 by 22 inch stroke; has steam shifting gear; hull has 5 water-tight compartments.

General Abbot.—Built in 1893 by R. M. Spedden Company; length, 82 feet; beam molded, 18 feet 2 inches; draft, 8 feet 6 inches; hull of steel, five-sixteenths inch to three-eighths inch thick; cabin of wood; boiler, Scotch marine, with superheater, 9 feet 6 inches by 10 feet, allowed 125 pounds steam pressure; engines, steeple compound, 12 by 22 by 20 inches; has steam shifting gear; hull has 3 water-tight compartments.

The construction of 10 new barges was authorized. They were to be standard gunwale barges of creosoted lumber. Contract for their construction was entered into, but on account of illness of the contractor but little has been done. Two of the barges are partially completed.

Repairs.—The work of repairing and maintaining the plant of the district was carried on as usual at the engineer depot in New Orleans. The following is a detail of the work done:

Steamer General John Newton.—Cabin repaired; boiler deck repaired; all new nosing put on boiler deck; 27 carlins put in boiler deck; 10 stationary fenders put in; 12 swinging fenders worked out; lower deck repaired and calked; 160 feet of plank shear put in; 160 feet of nosing put in on lower deck; all new canvas put down and given two coats of paint; 215 feet of plank shear was put down on main deck; 2 new stock knees put on head of boat; 2 new rudders made; 215 feet of nosing were put down on main deck; a new linen locker was made in state room of upper cabin; a new locker was made in the hold for paints and oils; 1,000 feet of new decking were put on main deck; chocks and two new heavy fair leads were put on main deck; an auxiliary boiler and an electric-light plant have been installed; the boat has been fitted with incandescent and arc lights throughout. Other current repairs have been made during the year. Cost, $2,161.02.

Tug General Gillespie.—Two after tanks cleaned; hull scraped from water line up and painted; pilot house painted and roof repaired; a new boiler feed pump was installed. Cost, $356.71.

Tug General Humphreys.—Docked in public dock; hull scraped and painted; after tank cleaned and painted; kitchen floor renewed and rotten floor timbers replaced with I beams; rudder repaired and given 4 inches additional balance; new stern bushing for tail shaft, and minor repairs. Cost, $430.36.

Tug General Abbot.—89 ordinary tubes and 12 stay tubes were put in boiler; new bottom and sides of combustion chamber were put in and general repairs made; repairs were made to the reversing engine; 2 pairs of brasses and 1 steel rod were made for the air pump; exhaust pipe from main engine to condenser, and 3 other copper pipes were repaired; 1 new brass casing was fitted in air pumps and a new cast iron follower head was made; 4 new steel follower head bolts were made; new steel piston was made for air pump; 4 valve seats faced up; a new bed was made in room aft of the pilot house for master of tug; the fair lead of tiller rope was repaired; the hull from water line up was scraped, cleaned, and given 2 coats of paint; all the old paint was removed from the cabin and 2 coats of spar varnish applied; deck was painted and the canvas roof was repaired and painted; the inside of boiler was thoroughly cleaned; boiler on outside below covering was also cleaned and painted; supports under after end of boiler were repaired, and an entire new set of coal bunkers were put in; new bridge wall castings were put in each furnace. Cost, $1,597.44.

Tug General Comstock.—Docked; butts of bottom planking calked; hull given a coat of hot tar to water line; above water line scraped and painted; roof repaired and jackstaff renewed; stack scraped and painted; engine overhauled. Cost, $130.44.

Launch Ruby.—Docked; outriggers and butts of all bottom planking calked and hull tarred to water line; rudder and rudder stock renewed; 2 new hog chain braces built and hog chain repaired; 2 stack knees repaired; 4 fenders made; engine room bulkhead and roof repaired; all machinery overhauled and repaired; all woodwork and one iron flange in wheel renewed; boat painted all over. Cost, $258.70.

Hydraulic dredge The Ram.—Hold and cabin cleaned; propelling wheel repaired; auxiliary boiler fitted with new set of tubes; roof repaired and painted; pumping engine repaired; 1 new crank shaft, 2 new crank pins and brasses for pins bored out and fitted to new pins; the pillow block of high pressure side was repaired by having 2 steel plates bolted to side of pillow block; a steel bolt, 2¼ by 6 inches long, was put in housing to tie it together; a new journal cap for high-pressure journal was made; main bearings for crank shaft were refitted and bored to suit shaft. Cost, $666.16.

Hydraulic Grader No 5.—Docked in public dock; bottom rakes and 3 seams on sides calked; 6 feet of new rake plank put in; hold cleaned and whitewashed; grader fitted for crew to live on board by adding kitchen, dining room, and staterooms; interior repainted. Cost, $597.28.

Mixer barge.—Docked and fitted with well; 20 deck beams reenforced; 1,000 feet decking and 100 feet of covering board put down; derrick, mixer, conveyor, boiler, engines, and pumps for manufacture of concrete ballast installed. Cost, $2,044.23.

Quarterboat New Orleans.—Hold cleaned and whitewashed; canvas on upper deck patched; 6 stationary fenders fitted in place; 2 pieces of planking put in side of hull; 1 new wooden cavil put in place; hull was calked from water line up and painted; inside of office was scrubbed and painted; outside of cabin was scrubbed and painted. Cost, $391.77.

Quarterboat Beta.—Sides and rakes calked; old paint burned off and cabin repainted; openings fitted with new wire screens. Cost, $160.92.

Barge No. 1.—Sides and rakes calked; 3 pieces rake plank renewed; 10 graving pieces put in gunwales; barge cleaned inside and painted on outside; all loose seams of bottom plank and butts on bottom calked; the barge was sheathed with 2 by 10 inch plank and calked; 9 new rake plank and 4 short pieces put in rake; 6 graving pieces put in side of gunwales; 4 new ladders were built and put in place at hatch openings. Cost, $315.85.

Barge No. 2.—Docked; all butts in bottom, 4 seams in bottom rakes and sides calked; 14 graving pieces put in gunwales; 50 feet of covering board put in deck; 3 iron bitts taken up; deck repaired and bitts put back; barge was painted and inside was cleaned. Cost, $129.85.

Barge No. 7.—Docked; bottom, sides, and rakes calked; 4 graving pieces put in gunwales; 40 feet of gunwales put in; new end of gunwales on each side of one end put in; 12 new rake plank put in; barge was sheathed with 2 by 10 inch timber; hold of barge cleaned and outside painted. Cost, $269.

Barge No. 10.—Docked; bottom, sides, and rakes calked; sides and rakes painted; hold cleaned and whitewashed. Cost, $146.88.

Barge No. 11.—Docked; bottom, sides, and rakes calked; 4 rake plank renewed; 2 bulkheads repaired; hold cleaned and whitewashed, and barge painted. Cost, $95.

Barge No. 13.—Docked; bottom, sides, and rakes calked; 4 rake plank renewed; hold cleaned and whitewashed and outside painted. Cost, $118.78.

Barge No. 16.—Camel docks put under each end; sides and rakes calked and painted; hold cleaned and whitewashed. Cost, $38.25.

Barge No. 18.—Docked; bottom, sides, and rakes calked; 1 bottom plank 3 by 10 inches by 12 feet renewed; 2 graving pieces put in gunwales; wooden timber heads replaced with 1 double and 2 single iron bitts; 3 sets of tie-rods put in under deck; barge cleaned inside and painted outside. Cost, $124.30.

Barge No. 19.—Docked; bottom, sides, and rakes calked; 8 floor beams reenforced with 4 by 8 inch by 10-foot timbers; 25 feet floor clamps put in; gunwales having been stove in, these were forced into position and clamped with pieces 4 by 10 inches by 6 feet; 1 graving piece 10 by 12 inches by 10 feet put in head block; 60 feet of decking renewed; barge cleaned inside and painted outside. Cost, $82.40.

Barge No. 20.—End dock put under barge; end of gunwales on one side cut off and a new piece put in 6 by 14 inches by 6 feet 6 inches; 5 new rake plank and 6 short pieces put in and rake calked. Cost, $40.95.

Barge No. 21.—Docked; 16 rake plank and 5 graving pieces put in; 11 filling-in pieces put in rake timbers; 6 new clamps put on gunwales; 6 floor and 6 deck beams repaired; barge sheathed with 2 by 10 inch planking; bottom, sides, and rakes calked; hold cleaned and whitewashed. Cost, $392.15.

Barge No. 22.—Docked; 8 rake plank, 5 clamps, 5 floor beams, 5 deck beams, and 6 graving pieces were put in; barge sheathed with 2 by 10 inch planking; bottom, sides, and rakes calked; sides and rakes painted. Cost, $223.50.

Barge No. 23.—Docked; 4 short pieces put in rakes, and 5 graving pieces in gunwales; 11 clamps put on gunwales; deck repaired and sheathed with 1 by 12 inch plank; gunwales sheathed with 2 by 10 inch planking; barge calked throughout, and hold cleaned and whitewashed. Cost, $379.82.

Barge No. 26.—Docked and calked; 14 new rake plank put in each rake; 6 short pieces of rake plank put in; end of gunwales cut off and a new piece 6 by 14 inches by 7 feet put in; the sides of barge were stiffened by 6 pieces of 6 by 10 inches bolted through sides of gunwales; 6 floor and 6 deck beams were put in; barge was sheathed with 2 by 10 inch planking; deck was sheathed with 1 by 10 inch planking and 4 graving pieces put in head block; inside of barge cleaned. Cost, $283.07.

Barge No. 27.—Docked; all butts of bottom plank, 2 bottom seams and rakes and sides calked; 10 new rake plank put in; 1 new head block 12 by 14 inches by 30 feet put in; side of barge reenforced; 11 pieces 6 by 10 inches by 7 feet on each side of barge was put in and bolted through gunwales; deck repaired; some large seams on deck calked; 2 new hatch coverings put in; barge was sheathed with 2 by 10 inch lumber bolted and spiked to gunwales; 40 feet of gunwales put in; inside of barge was cleaned and outside painted. Cost, $449.87.

Barge No. 30.—Rakes and sides calked; 2 graving pieces put in gunwales; hold cleaned and barge painted. Cost, $56.65.

Barge No. 31.—Camel dock under each end; 1 graving piece fitted in gunwale; sides and rake calked and painted; hold cleaned and whitewashed. Cost, $34.

Current repairs.—The vast number of small jobs incident to the maintenance of the 49 large pieces of plant, together with pontoons, skiffs, lighters, pump boat, etc., are included under this head. The cost of this item was, $1,896.95.

Care of plant.—The cost of caring for the plant while not in use, both at the engineer depot in New Orleans, La., and in Giles Bend, Miss., was $7,683.81.

Condition of plant.—I find that the work done during the past year on repairs, care, and maintenance of plant practically leaves it in the same condition as last year. The status quo has been maintained, and considering the perishable character of most of the plant this is at least satisfying. Details of the condition of the several pieces of plant, either by name or number, are given in the last annual report.

Conclusion.—With the steady increase in the size and number of the plant the the necessity of a permanent depot is becoming more and more urgent. The first cost of the existing plant, including auxiliary plant, tools, appliances, etc., was about $400,000. This plant can not be maintained in a serviceable condition for less than 5 per cent of its first cost per annum. The general belief is that plant of this character on the Mississippi River deteriorates at the rate of about 10 per cent per annum. The introduction of steel hulls for steam craft and the use of creosote and other wood preservatives in building barges, etc., modifies past conditions to about the extent here given.

Very respectfully, your obedient servant,

H. S. DOUGLAS,
Assistant Engineer.

Capt. CHAS. S. BROMWELL,
Corps of Engineers, U. S. Army.

APPENDIX 4 D.

REPORT OF SUPERINTENDENT W. E. KNOBLOCH ON LEVEES.

NEW ORLEANS, LA., *May 1, 1903.*

SIR: I have the honor to submit the following report on the levee work that has been done in the Lower Tensas, Atchafalaya, Lafourche, Barataria, Pontchartrain, and Lake Borgne levee districts for and during the period extending from May 1, 1902, to May 1, 1903:

Construction.—Although the usual methods of construction (by scrapers and wheelbarrows) were used in doing the greater portion of the levee building, yet 342,059 cubic yards of levee work have been done by machinery.

The same two machines, described in my report for 1901, were employed in doing the work, and the results demonstrate that it will be but a few years before the bulk of levee building will be done with machinery.

Though these machines did the work successfully and at a comparatively small cost, yet there is room for improvement, and each successive year's work ought to suggest changes that will permit of the work being done at a lower cost.

Muck or base ditches.—All existing embankments that were enlarged were free from leaks, and as the foundations on which new levees were built were considered secure, no muck or base ditch was cut.

Supervision.—No change has been made in the method of supervision, and the same method as was reported in my annual report for 1901 was continued.

Inspection.—Accompanied in each levee district by the inspector of that district I have inspected during the year the entire levee line of the Fourth district.

Protection against high water.—On March 11 the gauge at Cairo read 48.9 feet. and as the Ohio and its tributaries still remained in a flooded condition it was decided to prepare at once for the maintenance of the levees during the flood.

It was deemed necessary that all protection work should be supervised by some competent engineer, and therefore employees under you were assigned as follows:

Mr. H. S. Douglas, assistant engineer, to take charge of the upper end of the Lower Tensas district, from Bedford to Vidalia; Mr. W. C. Barton, junior engineer, the lower end of the Lower Tensas district, from Vidalia to Bougere; Mr. E. B. Geddes, assistant engineer, and Mr. C. H. Drake, junior engineer, the Atchafalaya district; Mr. Geo. Schoenberger, junior engineer, the Lafourche district; Mr. Paul Goddard, junior engineer, the Barataria and Lake Borgne districts; and I, the Pontchartrain district.

The amount of money available for protection work was the 10 per cent reserved from the allotments for levees. With such a small sum no very great amount of protection work could be undertaken, and most of this money was therefore expended in the purchase of lumber, nails, wheelbarrows, and tools, which were placed on United States barges. These barges were stationed at different points along the levee line, and the United States furnished tugs and steamboats with which to do the necessary towing. The different local levee boards were requested to furnish all the labor for such emergency work as might become necessary.

In the Pontchartrain district there are many miles of low levees and a greater number of miles of levees of very small and weak section. In 1892, 1893, and 1897 there were either one or more crevasses in this district, and as the water came up this year the district was spoken of as the "safety valve" of the lower end of the Mississippi River.

On March 12 I conferred with Mr. Hunter C. Leake, president of the board of commissioners for the Pontchartrain district, and it was agreed that the United States would furnish the lumber, nails, and tools, and the local levee board would furnish the labor for raising (capping) 21.62 miles of low levee which stood less than 1 foot above the 1897 high water. This capping was done by driving, at intervals of every 5 feet, stakes 2 by 2 inches by 4 feet, 2 feet into the crown of the levee, at a distance of 1 foot from the river edge of the crown. To these stakes were nailed planks 1 by 12 inches, the bottom of which rested for their entire length either on or in the ground. These planks were nailed on the land side of the stakes and were backed up with earth. The surface on which the earth was placed was broken. The earth, as a rule, was built up to a height of 2 feet, with a 5-foot base and a 2-foot crown. The cost of this work averaged 44 cents for each cubic yard of earth (including cost of lumber, nails, and labor), whereas the use of sacks in the same work would have increased the cost to $2.18 per cubic yard.

In many cases this work was done under the supervision of one of the United States inspectors, and the cost of the work as given above is only for that portion of the work which was under their supervision.

The work of capping was begun on March 15, and some of it was barely completed before the water reached a height above the top of the original crown of the levee.

In the Lower Tensas district 8,700 feet of levee was capped. Teams were used to do all of this work except about 600 feet, where sacks were used owing to the levee having become too soft to permit of teams traveling up and down its slope. In this district all of the work was done under the supervision of the United States, and 2,300 linear feet of capping was paid for by the United States at a cost of $478.

In the Lafourche district, 4,400 linear feet of levee was capped by the local levee board. In the Barataria district, 4.25 miles of levee was capped by the local levee board.

In the Lake Borgne district the capping was done by the local levee board and the property owners, the length capped being approximately 11.33 miles. This capping should be done in advance of the high water in order that all the attention, time, and labor might be given to such weak places in the levee line as developed when the water reached a sufficient height to disclose them.

Wave wash.—The levees in the Lake Borgne and Barataria districts are the only ones in the Fourth district which are in danger from wave wash, and in these districts most of the protection work consists in building and repairing the wooden revetment. In the other districts there were several places where the levee was badly wave washed, but at no time were they in any danger, and therefore very little work was done to guard against this danger, none at all being done under the supervision of the United States.

Sloughing.—Sloughing is caused by the earth on the land slope of a levee becoming so saturated with water as to become too soft to stand at the given slope.

In many places, where there are levees of small section, the land slope of the levee became wet and soft some time in advance of the highest water. The land base was immediately drained, and where the levee developed any inclination to slough, V-shaped ditches, 4 inches on top and 4 inches in depth, were cut down the land slope at intervals of every 3 feet. In most cases an improvement in the condition of the levee was immediately effected and no further trouble was experienced. In other cases, where this did not prevent sloughing, the trouble was attributed to the fact that the levee had not been compactly constructed and loose earth was placed on the river slope from the water's edge to the toe of the river slope. The crevices in the incompact embankment were thus filled and the sloughing arrested.

Leaks.—Leaks are caused by crayfish, muskrats, or other animals burrowing through the levee, or by a root or log decaying under the base or body of the levee.

During this high water there were a great many leaks in the levee line of the Pontchartrain district. All of these leaks were not dangerous, for the reason that often one hole on the land side was the outlet for several very small ones on the river side. When the water passing through these holes ran clear it was considered that there were several small inlets and that no danger existed. When, however, the water appeared muddy it was thought that the hole was enlarging and some serious danger was imminent. In these cases mud boxes were built from the levee on the river side and around these openings by driving two parallel rows of 4 by 4 inch pieces, tied by stringers of 2 by 6 inches, to which were nailed the sheet piling of 2 by 12 inches. These boxes were then filled with earth. All of the sheet piling was driven from 4 to 7 feet into the ground in order that the planks would cut off the leak by penetrating the holes where the orifices were located on the river side of the boxes. After these boxes were completed the height of the water between the boxes and the levee was soon lowered, and in a short while the flow through the holes was too weak to enlarge them further.

On April 13 a small leak was discovered at Waterloo (867 L.), and in less than one hour it was 18 inches in diameter and spouting earth and water. To counteract the pressure and to prevent further enlargement a circular wall of sacks filled with earth was built around this hole. The inner diameter of this wall at the bottom was 4 feet and its upper inner diameter was 10 feet. The circumference of its base was 180 feet and its height was about 12 feet. The water rose within this wall to within nearly 16 inches of the height of the water in the river. This counter pressure prevented further erosion and only about 10 gallons of water per second escaped through the interstices of the wall of sacks. From fear that the levee might be hollow and that another outlet would break out, a mud box 255 feet in length was built on the river side to secure this part of the levee. To brace this box four rows of cribwork were built on its land side, one side of the crib being used as one wall of the box. The outer crib, or the one next to the mud box, was filled with sacks of earth. The next crib was filled with sacks of earth to within 3 feet of the water surface, the next to within 7 feet of the water surface, and the inner one to a height of 3 feet. Work was started on this hole just in time to prevent a crevasse.

A crevasse occurred at Hymelia (928 R.) at 11 o'clock p. m., March 26, and when last reported was 700 feet wide. On April 5 the subsidence of the batture at Magnolia (1011 L.) carried with it a portion of the levee and caused a small crevasse. This was closed in one week. In the Grand Prairie section of the Lake Borgne district crevasses occurred, and are still open at Pinnaud's (1018 R.), Simme's (1019 R.), six between Grandison (1023 R.) and Vogt (1025 R.), and two between Cuselich Canal and Polite's Canal (1036 R.). These crevasses, with the exception of Simme's (1019 R.), are in levees upon which no work has ever been done by either the United States or by the State. They were built by riparian owners and are low in grade and small in section.

The highest water of this year, compared with that of 1897, was about five-tenths of a foot lower in the upper end of the Lower Tensas district and about six-tenths of a foot higher in the lower end of that district; from two-tenths to five-tenths of a foot lower in the Atchafalaya district; from five-tenths of a foot lower to nine-tenths of a foot higher in the Lafourche and Pontchartrain districts; and from nine-tenths of a foot to $1\frac{1}{10}$ feet higher in the Barataria and Lake Borgne districts.

LOWER TENSAS LEVEE DISTRICT.

The levee line has been extended at its lower end by the United States putting under contract for enlargement 172,000 linear feet of private levee and building 5,479 linear feet of new levee. A further extension was made by the State authorities building 13,200 linear feet of levee. Of the 13,200 linear feet of new levee built at the lower end of the line by the State authorities, 9,300 feet were washed away by water running through Bougere.

The building of a new levee by the State authorities at each of the following places, Vidalia (701 R.) and Fairview (728 R.), has caused the abandonment of 6,454 linear feet of levee, embracing 110,508 cubic yards. Of the 135.16 miles of effective levee in this district, there are on May 1, 1903, 513,691 linear feet or 97.29 miles built wholly or in part by the United States.

ATCHAFALAYA LEVEE DISTRICT.

Section 3 of Devall levee (823 R.) and Cypress Hall levee (823 R.), which remained incomplete at the date of the last annual report, were reawarded and satisfactorily completed.

The new levee built at Solitude (817 R.) has caused the abandonment of 10,639 linear feet of levee containing 280,000 cubic yards. Of the 127.77 miles of effective levee on May 1, 1903, there are 457,769 linear feet or 67.9 miles built wholly or in part by the United States.

LAFOURCHE LEVEE DISTRICT.

During the past year no levee construction has been done by the United States in this district. St. James levee (904 R.) and Chopin levee (906 R.) were contracted for on December 3, 1902, but no work has yet been done on either.

The building of a new levee by the State authorities at each of the following places, Rateau (888 R.), Cofield (891 R.), Point Pleasant (892 R.), Point Pleasant to Welcome (893 R.), and Avondale (952 R.), has caused the abandonment of 10,248 linear feet of levee, embracing 213,920 cubic yards. Of the 81.92 miles of effective levee in this district on May 1, 1903, there are 339,489 linear feet or 64.3 miles built wholly or in part by the United States.

BARATARIA LEVEE DISTRICT.

The construction of a new levee by the State authorities at each of the following places, Star (994 R.), and Leovy (1037 R.), has caused the abandonment of 3,760 linear feet of levee containing 12,500 cubic yards. Of the 71.66 miles of effective levee in this district on May 1, 1903, there are 208,256 linear feet, or 39.44 miles, built wholly or in part by the United States.

PONTCHARTRAIN LEVEE DISTRICT.

St. Mary Chapel levee (859 L.), which remained unfinished at date of last report, was completed.

The construction of a new levee by the State authorities at each of the following places, Hermitage (886 L.), and Hope (917 L.), caused the abandonment of 6,273 linear feet of levee embracing 125,000 cubic yards. Of the 125.57 miles of effective levee in this district on May 1, 1903, there are 523,526 linear feet, or 99.10 miles, built wholly or in part by the United States.

LAKE BORGNE LEVEE DISTRICT.

All work in this district was completed, and there now remains no contract in force.

The levee line was extended 5,250 linear feet by the construction of a new levee by the State authorities at Bayou Goubry. About one-half of the length of this levee was washed away by water running around its end.

The new levee built by the United States at Scarsdale (984 L.), and the new levee built by the State authorities at Devils Flats (1033 L.), caused the abandonment of 7,080 linear feet of levee containing 28,200 cubic yards. Of the 71.96 miles of effective levee in this district on May 1, 1903, 173,743 linear feet, or 32.90 miles, were built wholly or in part by the United States.

Abandoned levees.—The following is a table of the previous history of each length of levee which has been abandoned by the construction of new levees from May 1, 1902, to May 1, 1903:

Name.	Miles below Cairo.	District.	Length.	By whom built.	When built.	By whom enlarged.	When enlarged.
Vidalia	701 R.	Lower Tensas	1,139	Riparian owners.	1866	State	1891
Fairview	728 R.	do	2,520	United States	1882	United States	1896
Do	728 R.	do	1,100	do	1898		
Do	728 R.	do	1,695	Riparian owners.	1866	State	1888
Solitude	817 R.	Atchafalaya	815	State	1899	United States	1896
Do	817 R.	do	1,953	do	1890	do	
Do	817 R.	do	7,175	do	1880	do	
Do	817 R.	do	696	do	1892	do	
Rateau	888 R.	Lafourche	1,200	do	1885	do	1897
Cofield	891 R.	do	830	do	1881	State	1892
Point Pleasant	892 R.	do	5,622	do	1881	United States	1897
Point Pleasant to Welcome.	893 R.	do	825	do	1879	do	1897
Avondale	952 R.	do	1,230	do	1880	do	1896
Do	952 R.	do	741	do	1886	do	1896
Star	994 R.	Barataria	2,190	Not known	Not known	State	1897
Leovy	1037 R.	do	1,570	do	do	do	
Hermitage	866 L.	Pontchartrain.	526	United States	1895		
Do	866 L.	do	3,274	State	1897		
Hope	917 L.	do	517	do	1882	United States	1894
Do	917 L.	do	1,902	Riparian owners.		do	
Scarsdale	984 L.	Lake Borgne.	2,010	State	1892	do	1896
Do	984 L.	do	100	United States	1896	do	
Devils Flats	1033 L.	do	6,970	Riparian owners.	Not known		

The levee abandoned by the construction of a new levee at Vidalia (701 R.) was built by the riparian owners previous to 1866 and enlarged by the State authorities in 1891. The cost of the enlargement per year of service of the enlarged levee was less than one-twentieth of the cost of the new levee.

Of the 5,315 linear feet of levee abandoned by the building of a new levee at Fairview (728 R.), 2,520 feet were built by the United States in 1882, 1,100 feet in 1898, and 1,695 feet by the riparian owners previous to 1866. The 1,100 feet built by the United States in 1898 were not expected to have a life of twenty years, but were built to throw out a salient angle in the levee, which was expected to cave into the river at any time. The 2,520 feet built in 1882 were enlarged by the United States in 1898. The length of service of this enlarged levee, compared with the cost of the new levee, justified the expenditure for enlargement.

Of the 10,639 linear feet of levee abandoned by the building of a new levee at Solitude (817 R.), 815 feet were built by the State authorities in 1899 as a wing of levee and were not expected to have a life of twenty years; 1,953 feet in 1890, 7,175 feet in 1880, and 696 feet in 1892 and enlarged by the United States in 1896. The construction and enlargement of these lengths of levee were justifiable, for the reason that they were abandoned, not on account of any danger of their immediate cave into the river, but on account of their unsafe foundations.

The levee abandoned by the construction of a new levee at Rateau (888 R.) was built by the State authorities either in or previous to 1885 and enlarged by the United States in 1897. The cost of enlargement per year of service of the enlarged levee was less than one-twentieth of the cost of the new levee.

The levee abandoned by the construction of a new levee at Cofield (891 R.) was built more than twenty years ago and enlarged in 1892 by the State authorities. The cost of enlargement was less than one-twentieth of the cost of the new levee.

The levee abandoned by the construction of a new levee at Point Pleasant (892 R.) was built by the State authorities more than twenty years ago and enlarged by the United States in 1897. The cost of the enlargement was less than one-twentieth of the cost of the new levee.

The levee abandoned by the construction of a new levee at Point Pleasant to Welcome (893 R.) was built by the State authorities in 1879 and enlarged by the United States in 1897. The cost of the enlargement per year of service of the enlarged levee was less than one-twentieth of the cost of the new levee.

One thousand two hundred and thirty linear feet of the levee abandoned by the construction of new levees by the State authorities at Avondale were built more than twenty years ago, and 741 linear feet were built by the State authorities seventeen years ago. Both of these lengths were enlarged by the United States in 1896. The cost of the enlargement was less than one-twentieth of the cost of the new levees.

The date of the construction of the levee abandoned by the building of a new levee at Star is unknown. The abandoned levee was enlarged by the State in 1897. The cost of the enlargement per year of service of the enlarged levee was less than one-twentieth of the cost of the new levee.

Nothing is known of the date of the construction of the levee abandoned by the construction of a new levee at Leovy (1037 R.). Of the 3,800 linear feet of levee abandoned by the construction of a new levee at Hermitage (886 L.), 526 feet were built by the United States in 1895 and 3,274 feet by the State authorities more than twenty years ago. The location of the 526 feet built by the United States proved to have been an error in judgment, as the life of the levee was only eight years. Of the 2,473 linear feet of new levee at Hope (917 L.), 571 feet were built by the State authorities in 1893 as a wing of a levee and were not expected to give twenty years' service. One thousand nine hundred and two feet were built by riparian owners more than twenty years ago and were enlarged by the United States in 1894. The cost of the enlargement was less than one-twentieth of the cost of the new levee.

Of the 2,110 linear feet of levee abandoned by the building of a new levee at Scarsdale (984 L.), 100 feet were built as a wing by the United States in 1896 and were not expected to give twenty years' service. Two thousand and ten feet were built by the State authorities in 1892 and enlarged by the United States in 1896. The cost of the enlargement per year of service of the enlarged levee was less than one-twentieth of the cost of the new levee.

The levee abandoned by the building of a new levee at Devils Flats (1033 L.) was built by riparian owners and nothing is known of the history of its construction.

Very respectfully, your obedient servant,

W. E. KNOBLOCH,
Superintendent of Levees.

Capt. CHAS. S. BROMWELL,
Corps of Engineers, U. S. Army.

INDEX.

[The references in roman are to part and those in arabic to page. The letter "S" indicates the supplement.]

A.

Academy Creek, Ga. (*see* Brunswick Harbor) i, 267; ii, 1164
Acts of Fifty-seventh Congress, second session, affecting Corps of Engineers. iv, 2943
Acushnet River, Mass.:
  Harbor lines at New Bedford and Fairhaven i, 640, 820
  Improvement of New Bedford Harbor i, 92, 794
Agate Bay, Minn., improvement of harbor i, 465; ii, 1793
Agawam, Mass., South End Bridge across Connecticut River to Springfield. i, 652
Ahnapee Harbor, Wis., improvement of i, 480; ii, 1847
Alabama and Mississippi Railroad Company, bridge of i, 645
Alabama River, Ala., improvement of i, 302; ii, 1228
Alameda, Cal.:
  Bridge across San Leandro Bay to Bay Farm Island i, 646
  Improvement of Oakland Harbor i, 582; iii, 2186
Alameda County, Cal., bridge of i, 646
Albany, N. Y.:
  Harbor lines in Hudson River i, 640, 901
  Removal of wreck in Hudson River i, 139, 888
Albemarle and Chesapeake Canal, N. C., waterway via i, 226; ii, 1084
Albemarle Sound, N. C.:
  Improvement of waterway to Norfolk, Va., via Currituck Sound. i, 226; ii, 1084
  Improvement of waterway to Norfolk, Va., via Pasquotank River. i, 225; ii, 1083
  Removal of wreck in i, 228; ii, 1088
Alert (canal boat), removal of wreck of i, 139, 887
Alexandria, La.:
  Bridge across Red River to Pineville (Alexandria and Pineville Bridge Co.) i, 644
  Bridge across Red River to Pineville (Shreveport and Red River Valley Rwy. Co.) i, 643
Alexandria and Pineville Bridge Company, bridge of i, 644
Allegheny, Pa.:
  See also Pittsburg Harbor.
  Bridge across Allegheny River to Pittsburg (Union Bridge) i, 651
  Bridge across Ohio River to borough of McKees Rocks i, 644
Allegheny River, Pa.:
  Bridge at Brilliant Station, Pittsburg i, 649
  Bridge near Franklin (Big Rock Bridge) i, 651
  Bridge at Franklin (county bridge) i, 651
  Bridge at Herr Island, Pittsburg i, 649
  Bridge at Kennerdell i, 647
  Bridge between Pittsburg and Allegheny (Union Bridge) i, 651
  Construction of locks and dams i, 438; ii, 1680
  Harbor lines at Pittsburg i, 640; ii, 1706, 1709
  Improvement by open-channel work i, 439; ii, 1686
  Improvement of Pittsburg Harbor i, 432; ii, 1667
  Operating and care of Herr Island dam i, 439; ii, 1683
Allouez Bay, Wis. (*see* Duluth Harbor) i, 466; ii, 1794
Alloway Creek, N. J., improvement of i, 169, 988
Alpena Harbor, Mich., improvement of i, 523; iii, 1985
Altamaha River, Ga., improvement of i, 264; ii, 1158

Alva, Fla., bridge across Caloosahatchee River at Ferry Crossing ..... I, 647
Alviso Harbor, Cal., improvement of ..... I, 580; III, 2181
Ambrose channel, New York Harbor, N. Y., improvement of, including dredge construction ..... I, 139, 909, 979
Amite River, La., improvement of ..... I, 338; II, 1305
Amy, Dora (steamer), removal of wreck of ..... I, 194, 1024
Anacostia River, D. C.:
  Improvement of ..... I, 200; II, 1040
  Survey of United States land within flats of ..... I, 36
Anclote River, Fla., improvement of ..... I, 287; II, 1202
Andura (Nandua) Creek, Va., improvement of ..... I, 207; II, 1054
Ann, Cape, Mass.:
  Construction of harbor of refuge, with report relative to completion of project ..... I, 62, 740, 742
  Improvement of Rockport Harbor ..... I, 64, 743
Anoka, Minn., bridge across Mississippi River ..... I, 643
Apalachicola Bay and River, Fla.:
  Improvement of bay ..... I, 291; II, 1209
  Improvement of river, including the Cut-off ..... I, 292; II, 1212
  Removal of wreck at Apalachicola ..... I, 306; II, 1236
Appleton, Wis.:
  See also Fox River.
  Bridge across Fox River ..... I, 646
Appomattox River, Va., improvement of ..... I, 223; II, 1080
Appoquinimink River, Del., improvement of ..... I, 175, 995
Appropriations:
  Fortifications ..... I, 10, 14, 17
  Rivers and harbors ..... I, 35, 36
Aqueduct Bridge, Washington, D. C., repair of ..... I, 652; IV, 2483
Aqueduct, Washington, D. C. *See* Washington.
Aquia Creek, Va., improvement of ..... I, 207; II, 1055
Aransas Pass, Tex., improvement of ..... I, 359; II, 1345
Aransas Pass Harbor Company (*see* Aransas Pass) ..... I, 359; II, 1345
Arcata, Cal. (*see* Humboldt Harbor) ..... I, 591; III, 2199
Arch rock, San Francisco Harbor, Cal., removal of ..... I, 582; III, 2184
Arkansas River:
  Bridge between Arkansas and Desha counties, Ark ..... I, 643
  Bridge near Fort Gibson, Ind. T ..... I, 642
  Gauging (*see* Mississippi River Commission) ..... I, 639; S., 7, 8, 62, 97
  Improvement of ..... I, 376; II, 1407
Armament. *See* Fortifications.
Army War College, Washington, D. C., buildings for ..... I, 674; IV, 2931
Arthur Kill, N. Y. and N. J.:
  Improvement of ..... I, 147, 932
  Recommendation for stone monuments to mark established harbor lines. ..... I, 141
  Removal of wrecks ..... I, 158, 159, 955, 956
Arthur Lake, La. (*see* Mermentau River) ..... I, 340; II, 1308
Ashepoo River, S. C., waterway via, with estimates of cost ..... I, 255; II, 1132
Ashland, Ky.:
  See also Ohio River.
  Bridge across Ohio River to Ironton, Ohio ..... I, 644
Ashland and Ironton Bridge Company, bridge of ..... I, 644
Ashland Harbor, Wis., improvement of ..... I, 469; II, 1811
Ashley River, S. C., removal of wreck ..... I, 257; II, 1140
Ashtabula Harbor, Ohio, improvement of, including dredge construction ..... I, 553, 979; III, 2093
Assawaman Bay, Del., waterway via ..... I, 180, 1002
Assistants:
  Civilian, to engineer officers ..... I, 23
  On duty in Office of the Chief of Engineers ..... I, 676
Astoria, Oreg. (*see* Columbia River below Tongue Point) ..... I, 614; III, 2270
Atchafalaya Basin levee board of Louisiana, lock and dam in Bayou Lafourche ..... I, 641
Atchafalaya River, La.:
  Gauging (*see* Mississippi River Commission) ..... I, 639; S., 7, 8, 62, 97
  Rectification of mouth by Mississippi River Commission ..... I, 639; S., 3, 40
Atchison, Topeka and Santa Fe Railway Company, bridge of ..... I, 647

Atlantic City, N. J., bridges across Beach Thoroughfare and Lakes Ditch. I, 647, 648
Atlantic City, Va., harbor lines in Norfolk Harbor at .... I, 640; II, 1089
Atlantic County, N. J.:
  Bridges of, across Lakes Ditch and Beach Thoroughfare .... I, 648
  Bridge of, across Patcong Creek.................................... I, 651
Atlantic (South) States, removal of water hyacinths from Florida waters, including report on experiments made .... I, 279; II, 1184; IV, 2433
Attorney-General, reports by:
  On modification of bridges impeding navigation of Ohio River........ I, 37
  On title to lands embraced within flats of Anacostia River, D. C....... I, 36
Aux Becs Scies Lake, Mich. (*see* Frankfort Harbor)................. I, 518; III, 1975

B.

Babson, Harriet W. (schooner), removal of wreck of .... I, 53, 727
Back Bay of Biloxi, Miss. (*see* Biloxi Harbor)........................ I, 319; II, 1264
Back Cove, Portland, Me. (*see* Portland) .... I, 51, 725
Back River, Md., bridge across... I, 649
Back River, Mass. *See* Weymouth River.
Badger, Horace H. (schooner), removal of wreck of.................. I, 556; III, 2105
Bad River, Mich., improvement of.................................. I, 525; III; 1986
Bagaduce River, Me., improvement of .... I, 42, 716
Ballard, Wash.:
  Improvement of Puget Sound-Lake Washington waterway ..... I, 629; III, 2332
  Reexamination of Puget Sound-Lake Washington waterway, with plans and estimates of cost.. I, 630; III, 2340
Baltimore Harbor, Md.:
  Bridge at Spring Garden... I, 649
  Defenses of, including report on damp-proofing .... I, 9; IV, 2400
  Harbor lines in Patapsco River at Sparrow Point .... I, 640; II, 1033
  Improvement at Spring Garden.................................... I, 197; II, 1031
  Improvement of channel to .... I, 194; II, 1027
  Improvement of channel to Curtis Bay............................ I, 196; II, 1031
  Revised estimate of cost of increasing depth of channel to........ I, 195; II, 1032
Baltimore (steamer), removal of wreck of.............................. I, 324; II, 1272
Bangor Harbor, Me. (*see* Penobscot River) .... I, 43, 717
Barge No. 3, removal of wreck of, in Buffalo Bayou, Tex......... I, 360, 361; II, 1347
Bar Harbor, Me.:
  Construction of breakwater .... I, 39, 714
  Defenses of, including report on telephone booths and damp-proofing... I, 9; IV, 2371
Barracks, Washington, D. C..................... I, 17, 19, 23, 674, 675, 683; IV, 2934
Barren River, Ky., operating and care of lock and dam .... I, 461; II, 1776
Bartholomew Bayou, La. and Ark., improvement of............. I, 368, 370; II, 1379
Bass Rip, Mass., removal of wrecks .... I, 104, 820
Battalions of Engineers................................. I, 5, 18, 669, 686; IV, 2906
Batteries, gun and mortar... I, 9, 14, 17
Battery, the, New York, N. Y., removal of shoal in North River, off Pier A. I, 140, 911
Bayboro, N. C., bridge across Bay River................................. I, 652
Bay Farm Island, Oakland Harbor, Cal., bridge across San Leandro Bay... I, 646
Bayonne, N. J., removal of wreck in Newark Bay .... I, 159, 955
Bay Ridge channel, New York Harbor, N. Y., improvement of .... I, 142, 915
Bay River, N. C., bridge at Bayboro .... I, 652
Bayside channel, New York Harbor, N. Y., improvement of............ I, 139, 909
Beach Thoroughfare, N. J., bridges at Atlantic City .... I, 647, 648
Beaufort Harbor, N. C.:
  Improvement of.. I, 236; II, 1102
  Improvement of waterway to Newbern .... I, 235; II, 1101
  Improvement of waterway to New River........................... I, 236; II, 1103
Beaufort Harbor and River, S. C.:
  Defenses of Port Royal Sound, including report on damp-proofing . I, 9; IV, 2409
  Improvement of river... I, 256; II, 1139
  Improvement of waterway to Charleston, S. C..................... I, 255; II, 1138
  Improvement of waterway to Savannah (*see* Savannah Harbor).. I, 257; II, 1141
  Removal of logs from waterway to Charleston, S. C............... I, 257; II, 1140
Beautiful Island, Caloosahatchee River, Fla., bridge at .... I, 649
Beechridge, Ill., prevention of break in Mississippi River at.......... I, 392; II, 1455

- Belle River, Mich., improvement of .... I, 531; III, 1998
- Bellingham Bay, Wash. *See* New Whatcom Harbor.
- Benton Harbor, Mich., improvement of St. Joseph Harbor .... I, 501; III, 193
- Benton Harbor Canal, Mich. (*see* St. Joseph Harbor) .... I, 501; III, 193
- Bergen Point, N. J., removal of wreck in Newark Bay opposite .... I, 158, 954
- Bergen Point reef, Newark Bay, N. J., removal of wreck on .... I, 158, 954
- Berrian Island, East River, N. Y., harbor lines .... I, 640, 891
- Beverly Harbor, Mass., improvement of .... I, 68, 746
- Big Assawaman Bay, Del., waterway via .... I, 180, 1012
- Big Barren River, Ky., operating and care of lock and dam .... I, 461; II, 1776
- Big Hocking River, Ohio, ice harbor in Ohio River near .... I, 423; II, 1627
- Big Rock Bridge Company, bridge of .... I, 651
- Big Sandy Railway Company, bridge of .... I, 647
- Big Sandy River, W. Va. and Ky.:
  - Bridge across Levisa Fork at Whitehouse, Ky .... I, 647
  - Improvement of, including Tug and Levisa forks .... I, 448; II, 1742
  - Operating and care of lock and dam .... I, 450; II, 1747
- Big Sarasota Bay, Fla., improvement of .... I, 284; II, 1197
- Big Sioux River, S. Dak., ice harbor at Sioux City, Iowa .... I, 406; II, 1551
- Big Stone Lake, Minn., survey of .... I, 404; II, 1549
- Big Sunflower River, Miss., improvement of .... I, 373; II, 1396
- Biloxi Harbor, Miss., improvement of .... I, 319; II, 1264
- Bird, Harry E. (barge), removal of wreck of .... I, 165, 971
- Biscayne Bay, Fla., improvement of .... I, 277; II, 118
- Bismarck Harbor, N. Dak. (*see* Missouri River) .... I, 405; II, 155
- Black Lake, Mich., improvement of Holland Harbor .... I, 506; III, 194
- Black River, Ark. and Mo., improvement of .... I, 384; II, 143
- Black River, La., improvement of .... I, 366; II, 137
- Black River, Mich.:
  - Improvement at mouth .... I, 527; III, 199
  - Improvement at Port Huron .... I, 529; III, 199
- Black River, N. C.:
  - Bridge at Still Bluff .... I, 64
  - Improvement of .... I, 238; II, 110
- Black River, Ohio:
  - Bridge at Lorain .... I, 64
  - Improvement of Lorain Harbor .... I, 547; III, 20
- Black River, Wash., bridge in King County .... I, 64
- Black Rock Harbor, Conn. (*see* Bridgeport Harbor) .... I, 115, 84
- Black Rock Harbor, N. Y.:
  - Improvement of Buffalo entrance to .... I, 562; III, 214
  - Improvement of Lake Erie entrance to .... I, 562; III, 214
- Black Warrior River, Ala.:
  - Improvement above Tuscaloosa .... I, 309; II, 124
  - Improvement below Tuscaloosa .... I, 309; II, 124
  - Operating and care of locks and dams .... I, 315; II, 1253, 125
  - Removal of wreck .... I, 324; II, 127
- Blaine, James G. (schooner), removal of wreck of .... I, 103, 82
- Block Island, R. I.:
  - Construction of harbor of refuge .... I, 101, 815
  - Improvement of Great Salt Pond .... I, 102, 81
- Blood River, La. (*see* Tickfaw River) .... I, 338; II, 130
- Blossom rock, San Francisco Harbor, Cal., removal of .... I, 582; III, 218
- Boards (*see also* Commissions):
  - Of Engineers for Rivers and Harbors (*see also* Committee, etc.) .... I, 36, 6
  - Of Ordnance and Fortification .... I, 8, 9, 12, 1
  - On Fortifications or other Defenses (Endicott Board) .... I, 8,
  - The Board of Engineers .... I, 8, 6
- Boat railway, Columbia River, Oreg. and Wash .... I, 604; III, 22
- Boats:
  - *See also* Dredge *and* Snag boats, *and* Wrecks.
  - Rules governing running of steamers on certain streams .... I, 641
- Bœuf River, La. and Ark., improvement of .... I, 368, 370; II, 137
- Bogue Chitto, La.:
  - Bridge at Franklinton .... I, 650
  - Improvement of .... I, 336; II, 1300

- Bogue Falia, La., improvement of i, 337; ii, 1301
- Bogue Sound, N. C., improvement of waterway via i, 236; ii, 1103
- Boom Island, Mississippi River, Minneapolis, Minn., bridge at i, 650
- Boothbay Harbor, Me., removal of wreck at Ram Island light-house i, 53, 727
- Borden, Thomas (schooner), removal of wreck of i, 103, 819
- Boston Harbor, Mass.:
  - Bridges across Fort Point channel at Congress street and Mount Washington avenue i, 652
  - Defenses of, including report on damp-proofing i, 9; iv, 2374
  - Improvement of i, 77, 764
  - Wreck, removal of i, 88, 785
- Boulevards. *See* Roads.
- Braddock Point light station, Lake Ontario, N. Y., removal of wreck. i, 575; iii, 2169
- Brandywine Creek or River, Del.:
  - Bridge at Wilmington i, 649, 650
  - Improvement of Wilmington Harbor i, 174, 992
- Branford Harbor, Conn., improvement of i, 109, 839
- Braxton County, W. Va., bridge of i, 649
- Brays Bayou, Tex., bridge across i, 647, 648
- Brazos River, Tex.:
  - Improvement between Richmond and Old Washington i, 357; ii, 1343
  - Improvement between Velasco and Richmond i, 354, 357; ii, 1339
  - Improvement of mouth i, 358; ii, 1344
- Brazos River Channel and Dock Company (*see* Brazos River) i, 358; ii, 1344
- Brazos Santiago Harbor, Tex., improvement of i, 360; ii, 1346
- Breton Bay, Md., improvement of, including report on project by the Board of Engineers for Rivers and Harbors i, 201; ii, 1044, 1045
- Bridge Creek Landing, Va., wharf at i, 660; iv, 2517
- Bridgeport Harbor, Conn., improvement of i, 115, 846
- Bridges:
  - Alteration of, obstructing navigation i, 650, 651
  - Aqueduct Bridge, Washington, D. C., repair of i, 652; iv, 2483
  - Construction of, across navigable waters i, 642
  - Highway bridge, Washington, D. C., to replace Long Bridge. i, 643, 653; iv, 2484
  - In military divisions and departments i, 667; iv, 2478, 2899
  - Memorial Bridge, Washington, D. C i, 653; iv, 2484
  - Ohio River, impeding navigation i, 37
  - Rules governing opening of draws i, 642
  - Sakonnet River, R. I., alteration of Stone Bridge i, 94, 798
  - Yellowstone National Park, construction, etc., of, with report concerning technical features i, 666; iv, 2444, 2885
- Briggs, Maud (schooner), removal of wreck of i, 88, 785
- Brilliant Station, Pittsburg, Pa., bridge across Allegheny River i, 649
- Bristol, Me., bridge of town of i, 652
- Broad Creek River, Del., improvement of i, 192, 1022
- Broad Sound, Boston Harbor, Mass., improvement of i, 77, 764
- Bronx River, N. Y.:
  - Improvement of i, 126, 862
  - Removal of wrecks i, 138, 139, 887
- Brooklyn, N. Y. *See* New York Harbor.
- Browns Creek, N. Y., improvement of i, 133, 874
- Brunswick Harbor, Ga., improvement of i, 267; ii, 1164
- Brunswick River, N. C. (*see* Cape Fear River) i, 240; ii, 1109
- Bucksport Harbor, Me., improvement of i, 45, 719
- Budd Inlet, Wash. (*see* Olympia Harbor) i, 626; iii, 2330
- Buffalo Bayou, Tex.:
  - Improvement of i, 351; ii, 1334
  - Removal of wrecks i, 360, 361; ii, 1347
- Buffalo Fork, Snake River, Wyo., road to Fort Washakie i, 675; iv, 2937
- Buffalo Fork, White River, Ark., improvement of i, 382
- Buffalo Harbor, N. Y.:
  - Improvement of i, 559; iii, 2126
  - Improvement of Buffalo entrance to Erie Basin and Black Rock Harbor i, 562; iii, 2143
  - Improvement of channels in waters connecting Great Lakes i, 532; iii, 2001
  - Improvement of Lake Erie entrance to Erie Basin and Black Rock Harbor i, 562; iii, 2142

Buildings:
- Army War College . . . . . . I, 674; IV, 293
- Engineer School of Application . . . . . . I, 674, 675; IV, 2934
- Government Printing Office, Washington, D. C . . . . . . I, 673; IV, 2919
- Public, District of Columbia . . . . . . I, 658; IV, 2517
- School of Submarine Defense, Fort Totten, N. Y . . . . . . I, 13, 16

Bulkhead lines. *See* Harbor lines.

Burlington County, N. J., bridge of . . . . . . I, 647

Burlington County Traction Company, bridge across Rancocas River . . . . . . I, 647

Burlington Harbor, Vt., improvement of . . . . . . I, 69, 74

Burnite, Jas. K. (schooner), removal of wreck of . . . . . . I, 194, 1025

Burnt Mills, Tenn., bridge across Obion River . . . . . . I, 646

Buttermilk channel, New York Harbor, N. Y.:
- Improvement of . . . . . . I, 143, 917
- Removal of obstruction in . . . . . . I, 145, 925

Byram River, N. Y. (*see* Port Chester Harbor) . . . . . . I, 123, 855

C.

Cable galleries, tanks, etc . . . . . . I, 13, 15, 17

Cache River, Ark., improvement of . . . . . . I, 383; II, 1431

Cache River, Ill., prevention of Mississippi River from breaking into . . I, 392; II, 145

Caddo (Fairy) Lake, Tex. and La. (*see* Cypress Bayou) . . . . . . I, 365; II, 137

Cairo, Ill., prevention of break in Mississippi River near . . . . . . I, 392; II, 145

Calaveras River, Cal. (*see* Stockton and Mormon channels) . . . . . . I, 585; III, 219

Calcasieu Parish, La., bridge of . . . . . . I, 64

Calcasieu River, La.:
- Bridge across . . . . . . I, 64
- Improvement of mouth and passes . . . . . . I, 341; II, 13

California Débris Commission . . . . . . I, 638; III, 2

California, department of, reconnaissances and explorations . . . . . . I, 668; IV, 28

Caloosahatchee River, Fla.:
- Bridge at Beautiful Island . . . . . . I, 64
- Bridge at Ferry Crossing, Alva . . . . . . I, 64
- Improvement of . . . . . . I, 282, 283; II, 11

Calumet Harbor, Wis. (*see* Fox River) . . . . . . I, 489; II, 18

Calumet Harbor and River, Ill. and Ind.:
- Bridge at Cummings, Ill . . . . . . I, 643, 64
- Improvement of harbor . . . . . . I, 493; III, 18
- Improvement of river . . . . . . I, 494; III, 19

Cambridge Harbor, Md., improvement of . . . . . . I, 186, 10

Camden, Me., improvement of harbor at . . . . . . I, 46, 72

Camden, N. J.:
- Defenses of Delaware River . . . . . . I,
- Improvement of Cooper Creek . . . . . . I, 167, 98
- Improvement of Delaware River at . . . . . . I, 159, 957
- Removal of wreck in Cooper Creek . . . . . . I, 194, 1024

Canadian canal, St. Marys River, Ontario, commerce through . . I, 535; III, 2010, 2015

Canals, etc. (*see also* Waterways) . . . . . . I, 35, 3
- Albemarle and Chesapeake Canal, N. C., waterway via . . . . . . I, 226; II, 10
- Allegheny River, Pa., locks and dams . . . . . . I, 438, 439; II, 1680, 168
- Ashepoo River to South Edisto River, S. C., with estimates of cost (*see* Charleston-Beaufort waterway) . . . . . . I, 255; II, 11
- Barren River, Ky., lock and dam . . . . . . I, 461; II, 17
- Bee Tree Shoals Canal, Ala . . . . . . I, 418; II, 15
- Benton Harbor Canal, Mich. (*see* St. Joseph Harbor) . . . . . . I, 501; III, 19
- Big Barren River, Ky., lock and dam . . . . . . I, 461; II, 17
- Big Sandy River, W. Va. and Ky., locks and dams . . . . I, 448, 450; II, 1742, 17
- Big Stone Lake, Minn., reservoir dam . . . . . . I, 404; II, 15
- Black River, La., locks and dams . . . . . . I, 366; II, 13
- Black Warrior River, Ala., locks and dams . . . . . . I, 309, 315; II, 1244, 1253, 12
- Calaveras River, Cal., to Mormon channel, San Joaquin River . . I, 585; III, 219
- Canadian canal, St. Marys River, Ontario, commerce . . . . . . I, 535; III, 2010, 2015
- Cape Fear River above Wilmington, N. C., locks and dams . . . . . . I, 239; II, 110
- Cascades Canal, Columbia River, Oreg . . . . . . I, 606, 608; III, 2222, 22
- Chicago Drainage Canal, Ill . . . . . . I, 640
- Clubfoot and Harlowe Canal, N. C., waterway via . . . . . . I, 235; II, 1101

- Canals, etc.—Continued.
  - Colbert Shoals Canal, Ala .... I, 418; II, 1594
  - Columbia River, Cascades Canal .... I, 606, 608; III, 2222, 2224
  - Columbia River, The Dalles Rapids to Celilo Falls, locks and dams .... I, 604; III, 2221
  - Congaree River, S. C., lock and dam .... I, 251; II, 1130
  - Coosa River, Ga. and Ala., locks and dams .... I, 303, 306; II, 1230, 1235
  - Courtableau Bayou, La., lock and dam .... I, 334; II, 1295
  - Cumberland River, Tenn. and Ky., locks and dams .... I, 412, 414; II, 1581, 1585
  - Davis Island dam, Ohio River, Pa .... I, 435; II, 1671
  - Des Moines Rapids Canal, Mississippi River, with report on enlargement of locks and for dam at foot of rapids .... I, 395; II, 1491, 1500
  - Dismal Swamp Canal, Va. and N. C., waterway via .... I, 225; II, 1083
  - Duluth Canal, Minn., improvement of .... I, 466; II, 1794
  - Edisto (South) River to Ashepoo River, S. C., with estimates of cost (*see* Charleston-Beaufort waterway) .... I, 255; II, 1132
  - Estherville-Minim Creek Canal, S. C. (*see* Santee River) .... I, 248; II, 1127
  - Expenditures for operating and care .... I, 36
  - Fox River, Wis., locks and dams .... I, 489, 491; II, 1866, 1870
  - Galena River, Ill., lock and dam .... I, 395; II, 1498
  - Galveston and Brazos Canal, Tex., purchase of .... I, 355; II, 1339
  - Gowanus Canal, New York Harbor, N. Y. (*see* Gowanus Bay) .... I, 142, 915
  - Grand Rapids, Wabash River, lock and dam .... I, 457, 459; II, 1772, 1773
  - Great Kanawha River, W. Va., locks and dams .... I, 444, 445; II, 1721, 1723
  - Green River, Ky., locks and dams .... I, 461; II, 1775, 1776
  - Herr Island, Allegheny River, Pa., lock and dam .... I, 438, 439; II, 1680, 1683
  - Illinois and Mississippi Canal, Ill., construction of .... I, 496; III, 1920
  - Illinois and Mississippi Canal, Ill., operating and care .... I, 395; II, 1496
  - Illinois River, Ill., locks and dams .... I, 495, 496; III, 1915, 1917
  - Illinois River, Ill., survey for waterway via ... I, 494, 639; III, 1904; S., 7, 68, 167
  - Kampsville lock and dam, Illinois River, Ill .... I, 496; III, 1917
  - Kanawha River, W. Va., locks and dams .... I, 444, 445; II, 1721, 1723
  - Kentucky River, Ky., locks and dams .... I, 450, 451; II, 1748, 1753
  - Keweenaw Bay to Lake Superior, improvement and care .... I, 471, 472; II, 1815
  - Keweenaw Bay to Lake Superior, wreck .... I, 475; II, 1827
  - Lafourche Bayou, La., lock and dam .... I, 641
  - Lagrange lock and dam, Illinois River, Ill .... I, 496; III, 1917
  - Lake Washington Canal, Wash. *See* Puget Sound.
  - Levisa Fork, Big Sandy River, Ky., locks and dams .... I, 448; II, 1742
  - Little Kanawha River, W. Va., lock and dam .... I, 443, 444; II, 1718, 1719
  - Lockport, Ill., to St. Louis, Mo., survey for waterway I, 494, 639; III, 1904; S., 7, 68, 167
  - Louisville and Portland Canal, improvement and care .. I, 452, 455; II, 1763, 1765
  - Mermentau River, La., lock and dam .... I, 641
  - Michigan Lake to Sturgeon Bay, improvement and care .. I, 478, 480; II, 1841, 1846
  - Michigan Lake Superior Power Co.'s canal .... I, 641
  - Minim Creek-Estherville Canal, S. C. (*see* Santee River) .... I, 248; II, 1127
  - Mississippi River, Des Moines Rapids Canal, with report on enlargement of locks and for dam at foot of rapids .... I, 395; II, 1491, 1500
  - Mississippi River to Illinois River, construction of .... I, 496; III, 1920
  - Mississippi River to Illinois River, operating and care .... I, 395; II, 1496
  - Mississippi River, reservoirs, construction of .... I, 398; II, 1528
  - Mississippi River, reservoirs, operating and care .... I, 399; II, 1538
  - Mississippi River, St. Paul to Minneapolis, locks and dams .... I, 396; II, 1523
  - Monongahela River, locks and dams .... I, 427, 429, 431; II, 1652, 1658, 1660
  - Morgan Canal, Tex., improvement of (*see* Galveston ship channel .... I, 351; II, 1334
  - Morgan Canal, Tex., operating and care .... I, 353; II, 1337
  - Mormon channel, San Joaquin River, Cal., to Calaveras River .. I, 585; III, 2193
  - Mosquito Creek Canal, S. C. (*see* Santee River) .... I, 248; II, 1127
  - Muscle Shoals Canal, Ala .... I, 417, 419; II, 1594, 1605
  - Muskingum River, Ohio, locks and dams .... I, 446, 447; II, 1731, 1732
  - Navigation of, rules governing .... I, 641
  - North Carolina Cut, N. C., improvement of waterway via .... I, 226; II, 1084
  - Ohio River, Lock and Dam 1, at Davis Island, Pa .... I, 435; II, 1671
  - Ohio River, Locks and Dams 2–7 .... I, 435; II, 1672
  - Ohio River, Locks and Dams 8, 11, 13, 18, 19 .... I, 441; II, 1713
  - Ohio River, Lock and Dam 37 .... I, 426; II, 1645

Canals, etc.—Continued.
- Ohio River, Louisville and Portland Canal, improvement and care .... I, 452, 455; II, 1763, 1765
- Osage River, Mo., lock and dam .... I, 408; II, 1568
- Otter Tail Lake and River, Minn., reservoir dam .... I, 404; II, 1548
- Ouachita River, Ark. and La., locks and dams .... I, 366; II, 1373
- Plaquemine Bayou, La., lock .... I, 332; II, 1289
- Portage Lake canals, Mich., improvement and care .... I, 471, 472; II, 1815
- Portage Lake canals, Mich., wreck .... I, 475; II, 1827
- Port Arthur Canal, Tex., connection with Sabine Lake .... I, 344; II, 1314
- Puget Sound to Lake Washington, bridge at Seattle, Wash .... I, 645
- Puget Sound to Lake Washington, improvement .... I, 629; III, 2332
- Puget Sound to Lake Washington, reexamination .... I, 630; III, 2340
- Red Lake and Red Lake River, Minn., reservoir dam .... I, 403; II, 1548
- Regulations governing navigation of .... I, 641
- Rock River, Ill., construction of canal around .... I, 496; III, 1920
- Rock River, Ill., operating and care of canal around .... I, 395; II, 1496
- Rough River, Ky., lock and dam .... I, 463, 464; II, 1788, 1789
- Rules governing navigation of .... I, 641
- St. Clair Flats Canal, Mich., improvement and care ... I, 539, 540; III, 2033, 2034
- St. Louis, Mo., to Lockport, Ill., survey for waterway I, 494, 639 III, 1904; S., 7, 68, 167
- St. Marys Falls Canal, Mich., improvement and care.. I, 534, 535; III, 2006, 2010
- St. Marys Falls canals, Mich. and Ontario, commerce ..... I, 535; III, 2010, 2015
- St. Marys River, Mich., water-power canal at Sault Ste. Marie .... I, 641
- Salmon Bay, Wash., improvement of waterway via .... I, 629; III, 2332
- Salmon Bay, Wash., reexamination of waterway via .... I, 630; III, 2340
- Sanitary District of Chicago, Ill., canal of .... I, 640
- Seattle Canal, Wash., bridge at Seattle .... I, 645
- Seattle Canal, Wash., improvement of .... I, 629; III, 2332
- Seattle Canal, Wash., reexamination of .... I, 630; III, 2340
- Shilshole Bay, Wash., improvement of waterway via .... I, 629; III, 2332
- Shilshole Bay, Wash., reexamination of waterway via .... I, 630; III, 2340
- Six-mile Island, Allegheny River, Pa., lock and dam .... I, 438; II, 1680
- South Edisto River to Ashepoo River, S. C., with estimates of cost (*see* Charleston-Beaufort waterway) .... I, 255; II, 1132
- Springdale, Pa., lock and dam in Allegheny River .... I, 438; II, 1680
- Sturgeon Bay and Lake Michigan Canal, improvement and care .... I, 478, 480; II, 1841, 1846
- Superior Lake to Keweenaw Bay, improvement and care.... I, 471, 472; II, 1815
- Superior Lake to Keweenaw Bay, wreck .... I, 475; II, 1827
- Tennessee River, canals, locks, and dams .... I, 417, 419; II, 1591, 1594, 1605
- Tombigbee River, Ala., locks and dams .... I, 310, 312; II, 1246, 1248
- Traverse Lake, Minn., reservoir dam .... I, 404; II, 1549
- Trinity River, Tex., locks and dams .... I, 354; II, 1338
- Tug Fork, Big Sandy River, W. Va. and Ky., locks and dams... I, 448; II, 1742
- Turners Cut, N. C., waterway via .... I, 225; II, 1083
- Union Lake, Wash., improvement of waterway via .... I, 629; III, 2332
- Union Lake, Wash., reexamination of waterway via .... I, 630; III, 2340
- Wabash River, Grand Rapids lock and dam .... I, 457, 459; II, 1772, 1773
- Warrior River, Ala., locks and dams .... I, 309, 315; II, 1244, 1253, 1256
- Washington Lake to Puget Sound, bridge at Seattle, Wash .... I, 645
- Washington Lake to Puget Sound, improvement of waterway... I, 629; III, 2332
- Washington Lake to Puget Sound, reexamination of waterway.. I, 630; III, 2340
- Washita (Ouachita) River, Ark. and La., locks and dams .... I, 366; II, 1373
- White River, Ark., locks and dams .... I, 381; II, 1420
- Yamhill River, Oreg., lock and dam .... I, 609, 612; III, 2257, 2261

Canarsie Bay, N. Y., improvement of .... I, 130, 869

Cape Ann, Mass.:
- Construction of harbor of refuge in Sandy Bay, with report relative to completion of project .... I, 62, 740, 742
- Improvement of Rockport Harbor .... I, 64, 743

Cape Charles City Harbor, Va., improvement of .... I, 224; II, 1081

Cape Fear River, N. C.:
- Defenses of, including report on damp-proofing and on use of paint made of coal tar and kerosene oil .... I, 9; IV, 2408
- Improvement above Wilmington .... I, 239; II, 1105

- Cape Fear River, N. C.—Continued.
  - Improvement at and below Wilmington I, 240; II, 1109
  - Improvement of Northeast Branch I, 238; II, 1105
- Cape Henry, Va., defenses at I, 9
- Cape Poge light-house, Mass., removal of wreck I, 103, 819
- Cape Vincent Harbor, N. Y., improvement of I, 572; III, 2162
- Capitol, Washington, D. C., telegraph line I, 659; IV, 2517
- Carleton, P. J. (barge), removal of wreck of I, 145, 924
- Carlows Island, Me., bridge to Point Pleasant I, 652
- Carquines Straits, Cal., channel to the Golden Gate (*see* San Pablo Bay) I, 583; III, 2189
- Carrabelle bar and harbor, Fla., improvement of I, 290; II, 1207
- Carrabelle, Tallahassee and Georgia Railroad Company, bridges of I, 652
- Carriages, gun and mortar I, 10
- Carters Creek, Va.:
  - Improvement of I, 208; II, 1056
  - Removal of wreck I, 218; II, 1071
- Caruthersville Harbor, Mo. (*see* Mississippi River Commission) I, 639; S., 3, 40
- Carvers Harbor, Me., improvement of I, 48, 722
- Cascades Canal, Columbia River, Oreg.:
  - Construction of I, 606; III, 2222
  - Operating and care I, 608; III, 2224
- Casemates, mining I, 13, 15, 17
- Castlerock, Wash., bridge across Cowlitz River I, 648
- Catahoula Parish, La., bridge of I, 646
- Cedar Bayou, Tex., improvement of I, 354, 356; II, 1339
- Centennial Lake, Miss. (*see* Vicksburg Harbor) I, 370; II, 1385
- Central of Georgia Railway Company, bridge of I, 652
- Central Vermont Railway Company, bridge of I, 652
- Champlain Lake, N. Y. and Vt.:
  - Burlington Harbor, Vt., improvement of I, 69, 748
  - Defenses of I, 9
  - Narrows, improvement of I, 72, 752
  - North and South Hero islands, improvement of channel between I, 69
  - Plattsburg Harbor, N. Y., improvement of I, 72, 751
  - Wrecks between Whitehall, N. Y., and Larabee Landing, Vt., removal of. I, 73, 753
- Channels. *See* Rivers and harbors.
- Charles River, Mass. (*see* Boston Harbor) I, 78, 766
- Charleston Harbor, S. C.:
  - Defenses of, including report on damp-proofing I, 9; IV, 2409
  - Improvement of, including dredge construction I, 253, 972; II, 1134
  - Improvement of waterway to Beaufort, S. C I, 255; II, 1138
  - Improvement of waterway to McClellanville, with estimates of cost. I, 252; II, 1132
  - Removal of logs from waterway to Beaufort, S. C I, 257; II, 1140
- Charlevoix Harbor, Mich., improvement of I, 519; III, 1978
- Charlotte Harbor, Fla., improvement of I, 282; II, 1194
- Charlotte Harbor, N. Y.:
  - Improvement of I, 567; III, 2153
  - Water levels I, 665; IV, 2678
- Charts:
  - Land within flats of Anacostia River, D. C I, 36
  - Military and other I, 667, 673; IV, 2478, 2899
  - Northern and Northwestern Lakes I, 660, 665; IV, 2671
- Chatham Harbor, Mass.:
  - Improvement of I, 88, 785
  - Removal of wreck off Hardings Beach light I, 103, 820
- Chattahoochee River, Ga. and Ala., improvement of I, 296; II, 1218
- Cheboygan Harbor, Mich., improvement of I, 522; III, 1983
- Cheesequake Creek, N. J., bridge across I, 650
- Chefuncte River, La., improvement of I, 337; II, 1301
- Chehalis River, Wash., improvement of I, 623; III, 2327
- Chelsea Creek, Mass. (*see* Boston Harbor) I, 80, 767
- Chemicals, use of, in destroying the water hyacinth I, 279, 343; II, 1184, 1312; IV, 2433
- Chequamegon Bay, Wis. (*see* Ashland Harbor) I, 469; II, 1811
- Chesapeake and Ohio Railway Company, bridge of, across Levisa Fork, Big Sandy River, Ky I, 647

Chesapeake Bay, Md. and Va.:
  Defenses at entrance at Cape Henry, Va .... I, 9
  Improvement of Cape Charles City Harbor, Va .... I, 224; II, 1081
Chester River, Md., improvement of .... I, 187, 1010
Chicago, Burlington and Quincy Railroad Company, bridge of .... I, 648
Chicago Drainage Canal, Ill., connection of Chicago River with .... I, 640
Chicago Harbor and River, Ill.:
  Bridge across Little Calumet River .... I, 647
  Bridge across North Branch at Western avenue .... I, 648
  Bridge across South Branch at Randolph street .... I, 648
  Bridges across South Branch at Eighteenth street and at Loomis street. I, 649
  Bridge across South Fork of South Branch at Archer avenue .... I, 647
  Bridge at State street .... I, 646
  Drainage canal, connection with river .... I, 640
  Improvement of Calumet (South Chicago) Harbor .... I, 493; III, 1896
  Improvement of channels in waters connecting Great Lakes .... I, 532; III, 2001
  Improvement of outer harbor .... I, 491; III, 1887
  Improvement of river .... I, 492; III, 1892
Chicago, Milwaukee and St. Paul Railway Company, bridge of .... I, 649
Chickasahay River, Miss.:
  Bridge at Leakesville .... I, 645
  Improvement of .... I, 318; II, 1260
Chief of Engineers, officers on duty in Office of the .... I, 676
Chillicothe, Ill., bridge across Illinois River .... I, 647
China Basin, San Francisco Harbor, Cal., harbor lines north of .... I, 640; III, 2252
Chincoteague Bay, Va., improvement of waterway to Delaware Bay .... I, 180, 1002
Chincoteague light-house, Va., removal of wreck .... I, 194, 1024
Chinook River, Wash., bridge across .... I, 647
Chipola River, Fla.:
  Improvement of lower river .... I, 292; II, 1212
  Improvement of upper river .... I, 294; II, 1213
Chitto, Bogue, La.:
  Bridge at Franklinton .... I, 656
  Improvement of .... I, 336; II, 1300
Choctawhatchee River, Fla. and Ala., improvement of .... I, 298; II, 1226
Choptank River, Md.:
  Improvement of .... I, 187, 1012
  Improvement of Cambridge Harbor .... I, 186, 1006
Christiana River, Del., improvement of Wilmington Harbor .... I, 174, 992
Cincinnati, Ohio:
  Construction of Lock and Dam 37, Ohio River, below .... I, 426; II, 1645
  General improvement of Ohio River .... I, 423; II, 1627
City of Austin (vessel), removal of wreck of .... I, 271; II, 1171
Civilian assistants to engineer officers .... I, 23
Claiborne Harbor, Md., improvement of .... I, 185, 1008
Clark Fork, Columbia River, Wash. (*see* Pend Oreille River) .... I, 635; III, 2338
Clatskanie River, Oreg., improvement of .... I, 616; III, 2318
Clatsop County, Oreg., bridge of .... I, 649
Cleveland Harbor, Ohio:
  Bridges of Newburgh and South Shore Railway Company .... I, 650
  Bridges, municipal, at Jefferson street .... I, 647
  Improvement of, including dredge construction .... I, 549, 979; III, 2071
  Removal of wrecks .... I, 556; III, 2105
  Water levels .... I, 665; IV, 2673
Clinch River, Tenn.:
  Bridge at Dossett .... I, 644
  Improvement of .... I, 421; II, 1619
Clinton River, Mich., improvement of .... I, 531; III, 1998
Clubfoot and Harlowe Canal, N. C., waterway via .... I, 235; II, 1101
Clubfoot Creek, N. C., waterway via .... I, 235; II, 1101
Coanjock Bay, N. C., waterway via .... I, 226; II, 1084
Coast defenses. *See* Fortifications.
Cocheco River, N. H., improvement of .... I, 56, 734
Coeymans (North), N. Y., removal of wreck in Hudson River .... I, 139, 888
Cogswell, Jas. (barge), removal of wreck of .... I, 139, 888
Cohansey Creek, N. J., removal of wreck .... I, 194, 1024
Cohasset Harbor, Mass., improvement of, including report on project by the Board of Engineers for Rivers and Harbors .... I, 83, 773, 774

- Collar, B. L. (barge), removal of wreck of ... I, 138, 887
- College, War, Army, Washington, D. C., buildings for ... I, 674; IV, 2931
- Colleton County, S. C., bridge of ... I, 645
- Colorado, department of the, reconnaissances and explorations ... I, 668, 672; IV, 2916
- Columbia, department of the, reconnaissances and explorations ... I, 668, 672; IV, 2915
- Columbia River, Oreg. and Wash.:
  - Cascades Canal, construction of ... I, 606; III, 2222
  - Cascades Canal, operating and care ... I, 608; III, 2224
  - Celilo, Oreg., improvement above ... I, 602; III, 2218
  - Celilo Falls to The Dalles Rapids, boat railway ... I, 604; III, 2221
  - Celilo Falls to The Dalles Rapids, locks and dams ... I, 604; III, 2221
  - Clark Fork (*see* Pend Oreille River) ... I, 635; III, 2338
  - Gauging ... I, 619; III, 2321
  - Mouth of, defenses at, including report on construction methods and on speaking tubes ... I, 9; IV, 2423
  - Mouth of, improvement at, including dredge construction and report on project ... I, 614, 975; III, 2271, 2275
  - Mouth of, to Willamette River, improvement from ... I, 612; III, 2263
  - Three-mile Rapids, improvement at ... I, 604; III, 2221
  - Tongue Point, Oreg., improvement below ... I, 614, III, 2270
  - Vancouver, Wash., to Willamette River, improvement from ... I, 608; III, 2228
- Commencement Bay, Wash., improvement of Tacoma Harbor ... I, 627; III, 2331
- Commercial statistics, Sault Ste. Marie canals, Mich ... I, 535; III, 2010, 2015
- Commissions (*see also* Boards):
  - California Débris Commission ... I, 638; III, 2367
  - Mississippi River Commission ... I, 639; S. 3, 40
  - Permanent International Commission of Congresses of Navigation ... I, 639
- Committee on Rivers and Harbors, House of Representatives, reports submitted by Board of Engineers for Rivers and Harbors, in pursuance of resolution of ... I, 637
  - Breton Bay, Md ... I, 202; II, 1045
  - Cohasset Harbor, Mass ... I, 83, 774
  - Oconto Harbor, Wis ... I, 476; II, 1836
  - Patuxent River, Md ... I, 203; II, 1048
  - Scituate Harbor, Mass ... I, 84, 777
- Compton Creek, N. J., improvement of ... I, 154, 948
- Comstock, John (schooner), removal of wreck of ... I, 145, 924
- Conecuh River, Ala., improvement of ... I, 301; II, 1226
- Congaree River, S. C.:
  - Construction of lock and dam near Granby ... I, 251; II, 1130
  - Improvement by open-channel work ... I, 250; II, 1129
- Congresses of Navigation, Permanent International Commission of ... I, 639
- Conneaut Harbor, Ohio, improvement of, including dredge construction ... I, 555, 979; III, 2099
- Connecticut River, Mass. and Conn.:
  - Bridge at Hartford, Conn ... I, 644
  - Bridge between Springfield and Agawam, Mass. (South End Bridge) ... I, 652
  - Improvement below Hartford, Conn ... I, 107, 836
- Connecticut River Bridge and Highway District, bridge of ... I, 644
- Contentnia Creek, N. C., improvement of ... I, 232; II, 1096
- Contingencies of rivers and harbors, estimate of appropriation for ... I, 636
- Continuing contracts ... I, 36
  - Albemarle Sound, N. C., waterway via ... I, 225; II, 1083
  - Allegheny River, Pa., locks and dams ... I, 438; II, 1680
  - Ambrose channel, New York Harbor, N. Y ... I, 139, 909, 979
  - Appomattox River, Va ... I, 223; II, 1080
  - Arthur Kill, N. Y. and N. J ... I, 147, 932
  - Ashtabula Harbor, Ohio ... I, 553, 979; III 2093
  - Back Cove, Portland, Me ... I, 51, 725
  - Baltimore Harbor, Md., channel to Curtis Bay ... I, 196; II, 1031
  - Baltimore Harbor, Md., Patapsco River and channel to ... I, 194; II, 1027
  - Baltimore Harbor, Md., at Spring Garden ... I, 197; II, 1031
  - Bay Ridge channel, New York Harbor, N. Y ... I, 142, 915
  - Bee Tree shoals, Tennessee River, Ala ... I, 418; II, 1591, 1594
  - Big Sandy River, W. Va. and Ky., including the forks ... I, 448; II, 1742
  - Biscayne Bay, Fla ... I, 277; II, 1182
  - Black River, La ... I, 366; II, 1373

Continuing contracts—Continued.
Black River (Lorain) Harbor, Ohio ... I, 547; III, 2066
Black Rock Harbor, Buffalo, N. Y., Lake Erie entrance ... I, 562; III, 2142
Black Warrior River, Ala., above Tuscaloosa ... I, 309; II, 1244
Black Warrior River, Ala., below Tuscaloosa ... I, 309; II, 1245
Boston Harbor, Mass ... I, 77, 764
Bridgeport Harbor, Conn ... I, 115, 846
Buffalo Bayou, Tex ... I, 351; II, 1334
Buffalo Harbor, N. Y ... I, 559; III, 2126
Buffalo Harbor, N. Y., lake Erie entrance to Erie Basin and Black Rock Harbor ... I, 562; III, 2142
Calumet Harbor, Ill ... I, 493; III, 1896
Charleston Harbor, S. C ... I, 253, 972; II, 1134
Christiana River, Del ... I, 174, 992
Cleveland Harbor, Ohio ... I, 549, 979; III, 2071
Colbert shoals, Tennessee River, Ala ... I, 418; II, 1591, 1594
Columbia River, Oreg. and Wash., at the mouth ... I, 614, 975; III, 2271, 2275
Columbia River, Oreg. and Wash., The Dalles Rapids to Celilo Falls ... I, 604; III, 2221
Congaree River, S. C., between Columbia and Granby ... I, 251; II, 1130
Conneaut Harbor, Ohio ... I, 555, 979; III, 2099
Croatan Sound, N. C., waterway via ... I, 225; II, 1083
Cumberland Sound, Ga. and Fla ... I, 270, 974; II, 1168
Curtis Bay, Baltimore, Md., channel to ... I, 196; II, 1031
Deep Creek, Va ... I, 225; II, 1083
Delaware Bay, Del., harbor of refuge ... I, 164, 970
Delaware River, N. J., Pa., and Del ... I, 159, 957
Detroit River, Mich ... I, 540; III, 2036
Dog River, Miss ... I, 315; II, 1258
Duluth Harbor, Minn ... I, 466; II, 1794
East (Ambrose) channel, New York Harbor, N. Y ... I, 139, 909, 979
Elizabeth River, Va., Hospital Point, Norfolk ... I, 220; II, 1074
Elizabeth River, Va., waterway to sounds of North Carolina ... I, 225; II, 1083
Erie Basin, Buffalo, N. Y., Lake Erie entrance ... I, 562; III, 2142
Everett Harbor, Wash ... I, 631; III, 2334
Fall River Harbor, Mass ... I, 97, 803
Falls of Ohio River at Louisville, Ky ... I, 452; II, 1763
Galveston Harbor, Tex ... I, 348; II, 1321
Galveston Harbor, Tex., inner bar to Fifty-first street ... I, 350; II, 1328
Galveston-Houston waterway, Tex ... I, 351; II, 1334
Gloucester Harbor, Mass ... I, 65, 744
Gowanus Bay channels, New York Harbor, N. Y ... I, 142, 915
Grays Harbor and bar entrance, Wash ... I, 621; III, 2325
Great Lakes, channels in connecting waters of ... I, 532; III, 2001
Great Pedee River, S. C ... I, 245; II, 1120
Gulfport, Miss., channel to Ship Island Harbor ... I, 320; II, 1266
Hampton Roads, Va ... I, 221; II, 1076
Harbor Beach, Mich ... I, 526; III, 1989
Hay Lake channel, St. Marys River, Mich ... I, 537; III, 2027
Horn Island Harbor, Miss ... I, 315; II, 1258
Hospital Point, Norfolk Harbor, Va ... I, 220; II, 1074
Houston-Galveston waterway, Tex ... I, 351; II, 1334
Hudson River, N. Y ... I, 135, 877
Illinois and Mississippi Canal, Ill ... I, 496; III, 1920
Indiana Chute, Falls of Ohio River, Louisville, Ky ... I, 452; II, 1763
Kalamazoo River, Mich ... I, 504; III, 1945
Kennebec River, Me ... I, 50, 724
Kentucky River, Ky ... I, 450; II, 1748
Keweenaw Bay to Lake Superior, Mich., waterway ... I, 471; II, 1815
Levisa Fork, Big Sandy River, Ky ... I, 448; II, 1742
Lorain Harbor, Ohio ... I, 547; III, 2066
Louisville and Portland Canal, Ky ... I, 452; II, 1763
Loutre, Pass a, Mississippi River, sill across ... I, 325; II, 1276
Ludington Harbor, Mich ... I, 514; III, 1966
Marquette Harbor, Mich ... I, 473; II, 1820
Maumee Bay and River, Ohio (*see* Toledo Harbor) ... I, 542, 979; III, 2049
Michigan City outer harbor, Ind ... I, 498, 499; III, 1931

Continuing contracts—Continued.
- Michigan Lake-Sturgeon Bay Canal, including harbor of refuge.. I, 478; II, 1841
- Mississippi River, Head of Passes to Ohio River..... I, 639; S., 3, 40
- Mississippi River, between Missouri and Ohio rivers..... I, 390; II, 1445
- Mississippi River, between Missouri River and St. Paul..... I, 393; II, 1468
- Mississippi River, sill across Pass a Loutre..... I, 325; II, 1276
- Mississippi River, between St. Paul and Minneapolis..... I, 396; II, 1523
- Mississippi River, Southwest Pass..... I, 326, 980; II, 1277
- Mississippi River, Vicksburg Harbor, Miss..... I, 370; II, 1385
- Mobile Harbor, Ala..... I, 307; II, 1237
- Monongahela River, W. Va. and Pa..... I, 427, 429; II, 1652, 1658
- Mormon channel, San Joaquin River, Cal..... I, 585; III, 2193
- Narragansett Bay, R. I..... I, 95, 801
- Neebish channels, St. Marys River, Mich..... I, 537; III, 2027
- New Haven Harbor, Conn..... I, 110, 839
- New London Harbor, Conn..... I, 105, 833
- New York Harbor, N. Y., Ambrose channel..... I, 139, 909, 979
- New York Harbor, N. Y., Gowanus Bay channels..... I, 142, 915
- Norfolk Harbor, Va., Hospital Point..... I, 220; II, 1074
- Norfolk Harbor, Va., waterway to sounds of North Carolina..... I, 225; II, 1083
- Northern and Northwestern Lakes, channels connecting..... I, 532; III, 2001
- Oakland Harbor, Cal..... I, 582; III, 2186
- Ocmulgee River, Ga..... I, 266; II, 1161
- Ohio River, Dams Nos. 2–5..... I, 435; II, 1672
- Ohio River, Dams Nos. 8, 11, 13, and 18..... I, 441; II, 1713
- Ohio River, Dam No. 37..... I, 426; II, 1645
- Ohio River, Falls of, at Louisville, Ky..... I, 452; II, 1763
- Ouachita River, Ark. and La..... I, 366; II, 1373
- Pamlico Sound, N. C., waterway to Norfolk Harbor, Va..... I, 225; II, 1083
- Pascagoula River, Miss., below mouth of Dog River..... I, 315; II, 1258
- Pasquotank River, N. C., waterway via..... I, 225; II, 1083
- Passaic River, N. J..... I, 145, 927
- Pass a Loutre, Mississippi River, sill across..... I, 325; II, 1276
- Patapsco River, Md., and channel to Baltimore..... I, 194; II, 1027
- Patapsco River, Md., channel to Curtis Bay..... I, 196; II, 1031
- Patapsco River, Md., harbor of southwest Baltimore (Spring Garden)..... I, 197; II, 1031
- Pedee River, S. C..... I, 245; II, 1120
- Plaquemine Bayou, La..... I, 332; II, 1289
- Portage Lake, Mich., harbor of refuge..... I, 517; III, 1973
- Portland Harbor, Me., including Back Cove..... I, 51, 725
- Potomac River below Washington, D. C..... I, 200; II, 1038
- Providence River, R. I..... I, 95, 801
- Red Hook channel, New York Harbor, N. Y..... I, 142, 915
- Rockland Harbor, Me..... I, 47, 721
- Sacramento River, Cal..... I, 587; III, 2194
- St. Johns River, Fla., Jacksonville to the ocean..... I, 271, 976; II, 1173
- St. Joseph Harbor, Mich..... I, 501; III, 1937
- St. Marys River, Mich., at the falls..... I, 534; III, 2006
- St. Marys River, Mich., Hay Lake and Neebish channels..... I, 537; III, 2027
- Sandbeach harbor of refuge, Mich..... I, 526; III, 1989
- San Diego Harbor, Cal..... I, 575; III, 2171
- San Francisco Harbor, Cal..... I, 582; III, 2184
- San Joaquin River, Cal., Stockton and Mormon channels..... I, 585; III, 2193
- San Pablo Bay, Cal..... I, 583; III, 2189
- San Pedro Bay, Cal..... I, 576; III, 2173
- Saugatuck Harbor, Mich..... I, 504; III, 1945
- Savannah Harbor, Ga..... I, 257, 980; II, 1141
- Savannah River, Ga., between Augusta and Savannah..... I, 260; II, 1152
- Ship channel connecting waters of the Great Lakes..... I, 532; III, 2001
- Ship Island Harbor, Miss., channel to Gulfport..... I, 320; II, 1266
- South Chicago Harbor, Ill. (*see* Calumet Harbor)..... I, 493; III, 1896
- Southwest Baltimore Harbor, Md., at Spring Garden..... I, 197; II, 1031
- Southwest Pass, Mississippi River..... I, 326, 980; II, 1277
- Spring Garden, southwest Baltimore Harbor, Md..... I, 197; II, 1031
- Staten Island Sound, N. Y. and N. J..... I, 147, 932
- Stockton channel, San Joaquin River, Cal..... I, 585; III, 2193

Continuing contracts—Continued.
  Sturgeon Bay Canal, including harbor of refuge .... I, 478; II, 1841
  Superior Harbor, Wis .... I, 466; II, 1794
  Superior Lake to Keweenaw Bay, Mich., waterway .... I, 471; II, 1815
  Tacoma Harbor, Wash .... I, 627; III, 2331
  Tampa Bay, Fla .... I, 284; II, 1198
  Tennessee River, Ala., Colbert and Bee Tree shoals .... I, 418; II, 1591, 1594
  Toledo Harbor, Ohio .... I, 542, 979; III, 2049
  Tombigbee River, Ala., between mouth and Demopolis .... I, 309; II, 1245
  Trinity River, Tex., locks and dams .... I, 354; II, 1338
  Tug Fork, Big Sandy River, W. Va. and Ky .... I, 448; II, 1742
  Turners Cut, N. C., waterway via .... I, 225; II, 1083
  Union River, Me .... I, 41, 715
  Vicksburg Harbor, Miss .... I, 370; II, 1385
  Warrior River, Ala., above Tuscaloosa .... I, 309; II, 1244
  Warrior River, Ala., below Tuscaloosa .... I, 309; II, 1245
  Washita (Ouachita) River, Ark. and La .... I, 366; II, 1373
  Waukegan Harbor, Ill .... I, 488; II, 1864
  White River, Ark., locks and dams on upper portion .... I, 381; II, 1420
  Wilmington, Cal., outer harbor .... I, 576; III, 2173
  Wilmington, Del., harbor at .... I, 174, 992
  Winyah Bay, S. C .... I, 246; II, 1122
  Yazoo River, Miss., at the mouth .... I, 370; II, 1385
Contracts, continuing. *See* Continuing contracts.
Conway, S. C., bridge across Waccamaw River .... I, 650
Conway and Seashore Railroad Company, bridge of .... I, 650
Cooper Creek, N. J.:
  Improvement of .... I, 167, 986
  Removal of wreck .... I, 194, 1024
Coosa River, Ga. and Ala.:
  Improvement above East Tenn., Va. and Ga. R. R. bridge .... I, 303, 304; II, 1230
  Improvement below East Tenn., Va. and Ga. R. R. bridge .... I, 303, 305; II, 1233
  Operating and care of locks and dams .... I, 306; II, 1235
Coosawattee River, Ga., improvement of .... I, 303, 305; II, 1233
Coos Bay, Harbor, and River, Oreg.:
  Improvement of entrance to bay and harbor .... I, 595; III, 2209
  Improvement of river .... I, 597; III, 2211
Coquille River, Oreg., improvement of .... I, 593; III, 2205
Corney Bayou, La., improvement of .... I, 368, 370; II, 1379
Corps of Engineers:
  Engineer equipment of troops and civilian assistants to engineer officers. I, 23, 697
  Engineer School of Application .... I, 19, 674, 675, 689; IV, 2934
  Laws of 57th Congress, second session, affecting the .... IV, 2943
  Officers on duty in Office of the Chief of Engineers .... I, 676
  Personnel .... I, 3, 5, 18, 669, 686; IV, 2906
  Service of officers abroad and in the field, with troops .... I, 24
Coscob Harbor, Conn., improvement of .... I, 122, 854
Cottrell (schooner), removal of wreck of .... I, 281; II, 1187
Council Bluffs, Iowa, bridge across Missouri River to East Omaha, Nebr .... I, 642
Courtableau Bayou, La., improvement of .... I, 334; II, 1295
Cowlitz River, Wash.:
  Bridge across .... I, 648
  Improvement of .... I, 617; III, 2319
Craft, water:
  See also Dredge *and* Snag boats, *and* Wrecks.
  Rules governing running of steamboats on certain streams .... I, 641
Craigs Point, Manatee River, Fla., bridge at .... I, 643
Croatan Sound, N. C., improvement of waterway via .... I, 225; II, 1083
Crooked (Carrabelle) River, Fla. (*see* Carrabelle bar and harbor) .... I, 290; II, 1207
Cross Creek Township, W. Va., bridge across Ohio River to Steubenville, Ohio. I, 644
Cross ledge light-house, Delaware Bay, removal of wreck .... I, 165, 971
Croydon, Pa., bridge across Neshaminy Creek .... I, 646
Crystal River, Fla., improvement of .... I, 286; II, 1202
Cumberland River, Tenn. and Ky.:
  Bridge in Davidson County, Tenn .... I, 643
  Gauging (*see* Mississippi River Commission) .... I, 639; S., 7, 8, 62, 97
  Improvement above Nashville, Tenn .... I, 414; II, 1585

Cumberland River, Tenn. and Ky.—Continued.
  Improvement below Nashville, Tenn .... I, 412; II, 1581
  Removal of wreck at Dover Island Chute .... I, 417; II, 1589
Cumberland Sound, Ga. and Fla.:
  Improvement of, including dredge construction .... I, 270, 974; II, 1168
  Improvement of waterway between Savannah and Fernandina .. I, 269; II, 1166
  Removal of wrecks .... I, 271; II, 1171
Cummings, Ill., bridge across Calumet River at .... I, 643, 644
Current River, Ark., and Mo., improvement of .... I, 385; II, 1434
Currituck Sound, N. C., improvement of waterway via .... I, 226; II, 1084
Curtis Bay, Baltimore, Md., improvement of channel to .... I, 196; II, 1031
Cut-off, Apalachicola River, Fla., improvement of .... I, 292; II, 1212
Cuyahoga River, Ohio. *See* Cleveland Harbor.
Cypress Bayou, Tex. and La., improvement of .... I, 365; II, 1372

D.

Dade County, Fla., bridge of .... I, 646
Daisy (bugeye), removal of wreck of .... I, 218; II, 1071
Daisy (flatboat), removal of wreck of, in Buffalo Bayou, Tex .... I, 360, 361; II, 1347
Dalecarlia reservoir, Washington Aqueduct, D. C .... I, 654; IV, 2485
Dams. *See* Canals *and* Waterways.
D'Arbonne Bayou, La., improvement of .... I, 368, 370; II, 1379
Darien Harbor, Ga., improvement of .... I, 262; II, 1156
Davidson, Gen. William Lee, monument to .... I, 676; IV, 2939
Davis, Chas. H. (steamer), removal of wreck of .... I, 556; III, 2105
Davis Island dam, Ohio River, Pa.:
  Operating and care .... I, 435; II, 1671
  Survey of Pool No. 1 for increased depth and additional harbor facilities .... I, 434; II, 1688
Deal Island Harbor, Md., removal of wrecks .... I, 194, 1024
Débris, mining, in California .... I, 638; III, 2367
Deep Creek Branch, Elizabeth River, Va., waterway via .... I, 225; II, 1083
Defenses, seacoast. *See* Fortifications.
Delaware Bay and River, N. J., Pa., and Del.:
  Defenses of .... I, 9
  Delaware Breakwater, Del., maintenance and repair of .... I, 163, 969
  Harbor lines between Edgemoor and Christiana River .... I, 640, 981
  Harbor of refuge in bay, construction of .... I, 164, 970
  Improvement of river .... I, 159, 957
  Lewes, Del., iron pier near, maintenance and repair of .... I, 163, 968
  Marcushook, Pa., improvement of ice harbor .... I, 166, 984
  Waterway to Chincoteague Bay, Va., improvement of .... I, 180, 1002
  Wrecks, removal of .... I, 165, 971, 972
Delta Point, La. (*see* Mississippi River Commission) .... I, 639; S., 3, 40
Department of Justice. *See* Attorney-General.
Departments, Executive, Washington, D. C., telegraph line and improvement of grounds .... I, 659; IV, 2517
Departments, military, reconnaissances and explorations .... I, 667; IV, 2478, 2899
Depots, engineer .... I, 19, 21, 23, 694, 703, 705
Derelicts. *See* Wrecks.
Deschutes River, Wash.:
  Bridge at Olympia .... I, 645
  Improvement of Olympia Harbor .... I, 626; III, 2330
Des Glaises Bayou, La., bridges across .... I, 648
Des Moines Rapids Canal, Mississippi River:
  Examination for enlargement of locks, with estimates of cost, and for dam at foot of rapids .... II, 1500
  Operating and care of, including dry dock .... I, 395; II, 1491
Des Plaines River, Ill., survey for waterway from Lockport, Ill., to St. Louis, Mo .... I, 494, 639; III, 1904; S., 7, 68, 167
Details, technical, of engineering methods. *See* Technical details.
Detroit River, Mich.:
  Improvement of .... I, 540; III, 2036
  Improvement of channels in waters connecting Great Lakes .... I, 532; III, 2001
  Survey from Detroit to Lake Erie, final report on .... I, 542
  Surveys, etc. (*see* Northern and Northwestern Lakes) .... I, 660; IV, 2671
Disappearing gun carriages .... I, 10

Discharge measurements. *See* Gauging.
Dismal Swamp Canal, Va. and N. C., improvement of waterway via ... I, 225; II, 1083
District of Columbia. *See* Washington.
Dividing Creek (La Trappe River), Md., improvement of ... I, 191, 1019
Division, engineers ... I, 36
Division of the Philippines, reconnaissances and explorations ... I, 668, 669; IV, 2478, 2903
Divisions, engineer ... I, 36
Doboy bar, Ga., improvement of ... I, 263; II, 1156
Dock lines. *See* Harbor lines.
Dog River, Miss. (*see* Pascagoula River) ... I, 315; II, 1258
Dora, Amy (steamer), removal of wreck of ... I, 194, 1024
Dossett, Tenn., bridge across Clinch River ... I, 644
Double Bayou, Tex., improvement of ... I, 354; II, 1339
Dover Island Chute, Cumberland River, removal of wreck ... I, 417; II, 1589
Drawbridges:
  See also Bridges.
  Rules for opening of ... I, 642
Drawings. *See* Maps.
Dredge boats recently authorized:
  Arkansas River ... I, 376; II, 1407
  Ashtabula Harbor, Ohio ... I, 553, 979
  Charleston Harbor, S. C ... I, 253, 972
  Cleveland Harbor, Ohio ... I, 549, 979
  Columbia River, Oreg. and Wash., mouth of ... I, 614, 975
  Columbia River, Oreg. and Wash., from mouth to Willamette River ... I, 612; III, 2263
  Conneaut Harbor, Ohio ... I, 555, 979
  Cumberland Sound, Ga. and Fla ... I, 270, 974
  Fairport Harbor, Ohio ... I, 551, 979
  Florida, works in ... I, 280; II, 1186
  Fox River, Wis ... I, 489; II, 1866
  Grand River, Mich ... I, 509; III, 1956
  Key West Harbor, Fla ... I, 278, 980
  Michigan Lake, harbors on eastern shore ... I, 498, 979
  Mississippi River, Head of Passes to Ohio River ... I, 639; S., 3, 40
  Mississippi River, passes of ... I, 325, 326, 973, 980; II, 1276, 1277
  Monongahela River, Pa ... I, 429; II, 1658
  New York Harbor, N. Y ... I, 139, 979
  Pensacola Harbor, Fla ... I, 299, 977
  St. Johns River, Fla ... I, 271, 976
  Sandusky Harbor, Ohio ... I, 545, 979
  San Pedro (Wilmington), Cal., inner harbor ... I, 577; III, 2175
  Savannah Harbor, Ga ... I, 257, 980
  Southwest Pass, Mississippi River ... I, 325, 326, 980
  Tennessee River below Riverton, Ala ... I, 419; II, 1591, 1598
  Texas coast ... I, 354; II, 1339
  Toledo Harbor, Ohio ... I, 542, 979
  Willamette River, Oreg., below Portland ... I, 612; III, 2257
  Wilmington, Cal., inner harbor ... I, 577; III, 2175
Dredge No. 3, removal of wreck of, in Galveston Bay, Tex ... I, 360, 361; II, 1347
Duck Creek (Smyrna River), Del., improvement of ... I, 179, 1000
Duck Island Harbor, Conn., construction of harbor of refuge ... I, 108, 838
Duluth Canal and Harbor, Minn.:
  Harbor lines in Lake Superior ... I, 640; II, 1828
  Improvement of ... I, 466; II, 1794
  Improvement of channels in waters connecting Great Lakes ... I, 532; III, 2001
  Removal of wrecks in Lake Superior ... II, 1828
Dunbar, George (steamer), removal of wreck of ... I, 556; III, 2103
Dunkirk Harbor, N. Y., improvement of ... I, 558; III, 2124
Dunnellon Phosphate Company, improvement of Withlacoochee River by ... I, 289; II, 1203
Duwamish River, Wash. (*see* Puget Sound) ... I, 625; III, 2328
Duxbury Harbor, Mass., improvement of ... I, 85, 781
Dyer County, Tenn., bridge of ... I, 646

E.

- East (Ambrose) channel, New York Harbor, N. Y., improvement of. I, 139, 909, 979
- East Chester Bay, N. Y., bridge in Pelham Bay Park ... I, 650
- East Chester Creek, N. Y., improvement of ... I, 127, 864
- East, department of the, reconnaissances and explorations ... I, 668; IV, 2902
- Eastern Branch, Elizabeth River, Va. (*see* Norfolk Harbor) ... I, 219; II, 1074
- Eastern Branch, Potomac River. *See* Anacostia River.
- East Omaha, Nebr., bridge across Missouri River to Council Bluffs, Iowa .. I, 642
- East Pass, Carrabelle Harbor, Fla., improvement of ... I, 290; II, 1207
- East River, Ga. (*see* Brunswick Harbor) ... I, 267; II, 1164
- East River, N. Y.:
  - Harbor lines at North Brother Island, Lawrence Point, and Berrian Island, and between East Thirteenth and East Eighteenth streets, New York City ... I, 640, 888, 891, 895
  - Improvement of ... I, 131, 871
  - Removal of wreck ... I, 139, 887
- Echo Bay Harbor, N. Y., improvement of ... I, 126, 861
- Eddy, D. M., bridge of ... I, 648
- Edenton Bay, N. C., improvement of ... I, 227; II, 1086
- Edgemoor, Del., harbor lines in Delaware River to Christiana River ... I, 640, 981
- Edisto (South) River, S. C., waterway via, with estimates of cost ... I, 255; II, 1132
- Eel River, Mass. (*see* Plymouth Harbor) ... I, 86, 782
- Eighteen-mile Creek, N. Y. (*see* Olcott Harbor) ... I, 566; III, 2151
- Eldorado (barge), removal of wreck of ... I, 158, 954
- Eldorado and Bastrop Railway Company, bridge of ... I, 643
- Electrical connections at fortifications ... I, 14, 15, 16, 17
- Elizabeth, Pa., harbor lines in Monongahela River ... I, 640; II, 1698
- Elizabethport, N. J., removal of wreck in Arthur Kill ... I, 158, 159, 955
- Elizabeth River, N. J.:
  - Improvement of ... I, 154, 947
  - Removal of wreck ... I, 159, 955
- Elizabeth River, Va.:
  - Harbor lines at Atlantic City bridge, at mouth of Smith Creek ... I, 640; II, 1089
  - Improvement of Norfolk Harbor and its approaches, including Hospital Point ... I, 219; II, 1074
  - Improvement of waterway to Albemarle Sound, via Currituck Sound ... I, 226; II, 1084
  - Improvement of waterway to sounds of North Carolina, via Pasquotank River ... I, 225; II, 1083
  - Improvement of Western Branch ... I, 220; II, 1076
- Elkpoint, S. Dak. (*see* Missouri River) ... I, 405; II, 1551
- Elk River, Md., improvement of ... I, 182, 1003
- Elk River, W. Va., improvement of ... I, 446; II, 1729
- Embankments ... I, 13, 16, 17
- Emlin, C. (steamer), removal of wreck of ... I, 306; II, 1236
- Emory River, Tenn., bridge at Harriman ... I, 643
- Emplacements ... I, 10, 11
- Employees as civilian assistants to engineer officers ... I, 23
- Endicott Board ... I, 8, 9
- Engineer depots ... I, 19, 21, 23, 694, 703, 705
- Engineer divisions ... I, 36
- Engineer equipment of troops ... I, 23, 697
- Engineering methods, technical details of. *See* Technical details.
- Engineer officers, civilian assistants to ... I, 23
- Engineer School of Application ... I, 19, 674, 675, 689; IV, 2934
- Engineer troops. *See* Troops.
- Engineers, Battalions of ... I, 5, 18, 686; IV, 2906
- Engineers, Boards of. *See* Boards.
- Engineers, Corps of:
  - Engineer equipment of troops and civilian assistants to engineer officers ... I, 23, 697
  - Engineer School of Application ... I, 19, 674, 675, 689; IV, 2934
  - Laws of 57th Congress, second session, affecting the ... IV, 2943
  - Officers on duty in Office of the Chief of Engineers ... I, 676
  - Personnel ... I, 3, 5, 18, 669, 686; IV, 2906
  - Service of officers abroad and in the field, with troops ... I, 24

Engineers, division .... i, 36
Engineers, Office of the Chief of, officers on duty .... i, 676
Engineers, The Board of .... i, 8, 679
English Bayou, La., bridge across .... i, 647
Equipment, engineer, of troops .... i, 23, 697
Erie Basin, Buffalo, N. Y.:
  Improvement of Buffalo entrance to .... i, 562; iii, 2143
  Improvement of Lake Erie entrance to .... i, 562; iii, 2142
Erie Harbor, Pa., improvement of, use of land at Presque Isle Peninsula for water-supply purposes, and status of title .... i, 557; iii, 2115
Erie Lake (*see also* Northern and Northwestern Lakes):
  Dredge boat for harbors on. *See* Dredge boats, etc.
  Removal of wrecks .... i, 556; iii, 2103
  Water levels .... i, 665, iv, 2678
Escambia River, Fla., improvement of .... i, 301; ii, 1226
Esopus Creek, N. Y. (*see* Saugerties Harbor) .... i, 136, 883
Estherville-Minim Creek Canal, S. C. (*see* Santee River) .... i, 248; ii, 1127
Estimates of appropriations required:
  Fortifications .... i, 17
  Rivers and harbors, etc .... i, 36, 636
Eureka, Cal. (*see* Humboldt Harbor) .... i, 591; iii, 2199
Evansville, Ind. (*see* Ohio River) .... i, 423; ii, 1627
Evaporation, outflow, and rainfall in valley of Northern and Northwestern Lakes .... i, 665; iv, 2855
Everett, Mass., bridge across Malden River to Medford .... i, 650
Everett Harbor, Wash., improvement of .... i, 631; iii, 2334
Examinations of rivers and harbors:
  Estimate of appropriation for .... i, 636
  Required to be made by act of 1902 .... i, 36
Executive Departments, Washington, D. C., telegraph line and improvement of grounds .... i, 659; iv, 2517
Executive Mansion and office, Washington, D. C .... i, 658; iv, 2517
Exeter River, N. H., improvement of .... i, 57, 735
Explorations and reconnaissances, military, with report on technical features of engineer operations in the former department of North Philippines, and present Department of Luzon .... i, 667; iv, 2478, 2903

F.

Fairhaven Harbor, Mass.:
  Harbor lines .... i, 640, 820
  Improvement of New Bedford Harbor .... i, 92, 794
Fairmont, W. Va., bridge across Monongahela River .... i, 651
Fairport Harbor, Ohio:
  Improvement of, including dredge construction .... i, 551, 979; iii, 2084
  Removal of wreck .... i, 556; iii, 2106
Fairy Lake, Tex. and La. (*see* Cypress Bayou) .... i, 365; ii, 1372
Falia, Bogue, La., improvement of .... i, 337; ii, 1301
Fall River Harbor, Mass., improvement of .... i, 97, 803
Falls of Ohio River, Louisville, Ky.:
  Improvement of .... i, 452; ii, 1763
  Operating and care of Louisville and Portland Canal .... i, 455; ii, 1765
False Egg Island Point, Delaware Bay, removal of wreck .... i, 165, 971
Feather River, Cal.:
  Improvement of .... i, 587; iii, 2194
  Improvement of, by California Débris Commission .... i, 638; iii, 2368
Fenwicks Island shoal, Md., removal of wreck .... i, 194, 1024
Fernandina, Fla.:
  Improvement of Cumberland Sound .... i, 270; ii, 1168
  Improvement of waterway to Savannah, Ga .... i, 269; ii, 1166
Ferry Crossing, Caloosahatchee River, Alva, Fla., bridge at .... i, 647
Ferry (Fairy) Lake, Tex. and La. (*see* Cypress Bayou) .... i, 365; ii, 1372
Fidelia (barge), removal of wreck of .... i, 103, 820
Field:
  Reconnaissances, explorations, etc., in the .... i, 667; iv, 2478, 2899
  Services of officers of the Corps of Engineers in the, with troops .... i, 24
Filtration plant, Washington Aqueduct, D. C., with report concerning preliminary treatment of Potomac water .... i, 657; iv, 2505, 2511
Finders, range and position .... i, 12, 15, 17

Fire Island Inlet, N. Y. (*see* Great South Bay) ... i, 134, 875
Fisher, Antoinette (barge), removal of wreck of ... i, 159, 955
Fisher, Leon (barge), removal of wreck of ... i, 159, 955
Fishing Creek, N. C., improvement of ... i, 230; ii, 1093
Five-mile River Harbor, Conn., improvement of ... i, 119, 850
Flag River, Wis. (*see* Portwing Harbor) ... i, 468; ii, 1809
Flat Lake, La. (*see* Grand River) ... i, 332; ii, 1289, 1312
Flint River, Ga., improvement of ... i, 295; ii, 1215
Flint River, Mich., improvement of ... i, 525; iii, 1986
Florence, Oreg., examination and survey of Siuslaw River at and near ... i, 599; iii, 2229
Florida:
  Defenses of coast, including report on damp proofing ... i, 9; iv, 2413
  Dredge boat for Key West Harbor ... i, 278, 980
  Dredge boat for Pensacola Harbor ... i, 299, 977
  Dredge boat for St. Johns River ... i, 271, 976
  Dredge and snag boat for works in ... i, 280; ii, 1186
  Removal of water hyacinths from waters in, including report on experiments made ... i, 279; ii, 1184; iv, 2433
Florida Coast Line Canal and Transportation Company (*see* Indian River) ... i, 276; ii, 1181
Florida East Coast Railway Company:
  Construction of basin at Miami, Fla., by ... i, 277; ii, 1182
  Construction of bridge by ... i, 648
Florida Southern Railroad Company, bridge of ... i, 649
Flushing Bay, N. Y., improvement of ... i, 129, 868
Footbridge across Potomac River at Washington, D. C., to replace Long Bridge ... i, 643, 653; iv, 2484
Foote, Fort, Potomac River, Md ... i, 17, 18, 685
Foreign possessions. *See* Insular possessions.
Fore River, Mass. *See* Weymouth River.
Forked Deer River, Tenn., improvement of ... i, 411; ii, 1579
Fort Foote, Potomac River, Md ... i, 17, 18, 685
Fort Gibson, Ind. T., bridge across Arkansas River near ... i, 642
Fortifications (*see also* Technical details):
  Appropriations required for 1904–5, estimates of ... i, 17
  Board of Engineers, The ... i, 8, 679
  Board of Ordnance and Fortification ... i, 8, 9, 12, 16
  Board on Fortifications or other Defenses (Endicott Board) ... i, 8, 9
  Building for School of Submarine Defense ... i, 13, 16
  Carriages, gun and mortar ... i, 10
  Financial statement ... i, 14
  General statement, suggestions, and progress of work ... i, 8, 9
  Gun and mortar batteries ... i, 9, 14, 17
  Insular possessions ... i, 8, 9, 14, 17
  Preservation and repair of ... i, 12, 15, 17
  Projects ... i, 8, 9, 16, 17
  Range and position finders ... i, 12, 15, 17
  Searchlights and electrical connections, with notes on projectors ... i, 14, 15, 16, 17; iv, 2425
  Sea walls and embankments ... i, 13, 16, 17
  Sites ... i, 13, 14, 15, 17
  Submarine mines ... i, 13, 15, 17
  Supplies for seacoast defenses ... i, 12, 16, 17
Fort Leavenworth, Kans.:
  Engineer depot at ... i, 21, 23, 703
  Engineer troops at ... i, 5
Fort Lee, N. J., harbor lines in Hudson River ... i, 640, 905
Fort Pierre, S. Dak. (*see* Missouri River) ... i, 405; ii, 1551
Fort Point channel, Boston, Mass.:
  Bridges at Congress street and Mount Washington avenue ... i, 652
  Improvement of ... i, 79, 767
Fort Totten, N. Y., building for School of Submarine Defense ... i, 13, 16
Fort Washakie, Wyo., road to Buffalo Fork, Snake River ... i, 675; iv, 2937
Fort William McKinley, Manila Bay, P. I ... iv, 2481, 2907
Fox River, Wis.:
  Bridge at Appleton ... i, 646
  Bridge at Oshkosh ... i, 645

Fox River, Wis.—Continued.
Harbor lines at Oshkosh and Greenbay .... I, 640; II, 1883, 1884
Improvement of .... I, 489; II, 1866
Improvement of Greenbay Harbor .... I, 477; II, 1839
Operating and care of locks and dams .... I, 491; II, 1870
Franconia (vessel), removal of wreck of .... I, 271; II, 1171
Frankfort Harbor, Mich., improvement of .... I, 518; III, 1975
Franklin, La., bridge across Bayou Teche .... I, 650
Franklin, Pa.:
Bridge across Allegheny River at (county bridge) .... I, 651
Bridge across Allegheny River near (Big Rock Bridge) .... I, 651
Franklinton, La., bridge across Bogue Chitto .... I, 650
French Broad River, Tenn., improvement of .... I, 420; II, 1616
Frenchman Bay, Me., defenses of, including report on telephone booths and damp-proofing .... I, 9; IV, 2371
Friend, Lottie K. (schooner), removal of wreck of .... I, 165, 972

G.

Galena River, Ill., operating and care of lock and dam .... I, 395; II, 1498
Gallipolis, Ohio, ice pier (*see* Ohio River) .... I, 423; II, 1627
Galveston and Brazos Canal, Tex., purchase of .... I, 355; II, 1339
Galveston Bay and Harbor, Tex.:
Defenses of, including report on damp-proofing .... I, 9, 16; IV, 2416
Improvement of Galveston-Texas City channel .... I, 351; II, 1331
Improvement of harbor .... I, 348; II, 1321
Improvement of harbor from inner bar to Fifty-first street .... I, 350; II, 1328
Improvement of waterway to Houston .... I, 351; II, 1334
Improvement of West Bay .... I, 354, 356; II, 1339
Plan and estimate of cost of protection of harbor, etc., from storms .... I, 349; II, 1348
Removal of wrecks .... I, 360, 361; II, 1347
Galveston, Harrisburg and San Antonio Railway Company, bridge of .... I, 647, 648
Gasconade River, Mo., improvement of .... I, 409; II, 1574
Gauging:
Columbia River, Oreg. and Wash .... I, 619; III, 2321
Michigan Lake, variations in surface level on east shore .... I, 498
Mississippi River and principal tributaries .... I, 405, 639; II, 1549; S., 7, 8, 62, 97
Northern and Northwestern Lakes, including report on outflow, rainfall, and evaporation .... I, 665; IV, 2678, 2855
Gauley River, W. Va., improvement of .... I, 446; II, 1728
Gedney channel, New York Harbor, N. Y., improvement of .... I, 139, 909
Genesee River, N. Y. (*see* Charlotte Harbor) .... I, 567; III, 2153
George Lake, St. Johns River, Fla. (*see* Volusia bar) .... I, 274; II, 1179
Georges River, Me., improvement of .... I, 49, 723
Georgetown, D. C. *See* Washington, D. C.
Georgetown Harbor, S. C. (*see* Winyah Bay) .... I, 246; II, 1122
Gibson, Fort, Ind. T., bridge across Arkansas River near .... I, 642
Gillen, Edward (tug), removal of wreck of .... II, 1828
Glencove Harbor, N. Y., improvement of .... I, 129, 867
Glenifer (schooner), removal of wreck of .... I, 542; III, 2046
Gloucester Harbor, Mass., improvement of .... I, 65, 744
Golconda, Ill. (*see* Ohio River) .... I, 423; II, 1627
Golden Gate, Cal., channel to Karquines Straits (*see* San Pablo Bay) I, 583; III, 2189
Goshen Creek, N. J., improvement of .... I, 170, 989
Gosport Harbor, N. H. (*see* Isles of Shoals Harbor) .... I, 55, 733
Government Printing Office, Washington, D. C.:
Construction of new building for .... I, 673; IV, 2919
Telegraph line .... I, 659; IV, 2517
Government telegraph line, Washington, D. C. .... I, 659; IV, 2517
Governors Island, New York Harbor, N. Y., enlargement of .... I, 144, 920
Gowanus Bay, Canal, and Creek, N. Y.:
Bay Ridge and Red Hook channels, including Gowanus Canal, improvement of .... I, 142, 915
Gowanus Creek, removal of wreck .... I, 145, 924
Gowanus Creek channel, improvement of .... I, 143, 919
Grand Calumet River, Ill. and Ind. (*see* Calumet River) .... I, 494; III, 1901

Grand Haven Harbor, Mich.:
  Bridge across Grand River to Spring Lake .... I, 649
  Improvement of .... I, 508; III, 1952
Grand Marais, Mich., improvement of harbor of refuge .... I, 474; II, 1824
Grand Marais, Minn., improvement of harbor .... I, 464; II, 1791
Grand Rapids, Mich.:
  Bridge across Grand River .... I, 646
  Improvement of Grand River .... I, 509; III, 1956
Grand Rapids, Wabash River, lock and dam .... I, 457, 459; II, 1772, 1773
Grand River, La., improvement of .... I, 332; II, 1289, 1312
Grand River, Mich.:
  Bridge at Grand Rapids .... I, 646
  Bridge between Spring Lake and Grand Haven .... I, 649
  Improvement of .... I, 509; III, 1956
  Improvement of Grand Haven Harbor .... I, 508; III, 1952
Grand River, Ohio (*see* Fairport Harbor) .... I, 551, 979; III, 2084
Grand River Toll Bridge Company, bridge of .... I, 649
Grant statue, Washington, D. C .... I, 658; IV, 2517
Grant (Army transport), conversion of, into dredge .... I, 614, 975
Grays Harbor, Wash.:
  Improvement of, between Aberdeen and the entrance .... I, 623; III, 2327
  Improvement of, including bar entrance .... I, 621; III, 2325
Great Kanawha River, W. Va.:
  Improvement of .... I, 444; II, 1721
  Operating and care of locks and dams .... I, 445; II, 1723
Great Lakes:
  Commercial statistics, Sault Ste. Marie canals, Mich .... I, 535; III, 2010, 2015
  Defenses of .... I, 8, 9
  Dredge boat for harbors on Lake Erie. *See* Dredge boats, etc.
  Dredge boat for harbors on eastern shore of Lake Michigan .... I, 498, 979
  Improvement of channels in waters connecting .... I, 532; III, 2001
  Outflow, rainfall, and evaporation in valley of .... I, 665; IV, 2855
  Survey of waters connecting lakes Superior and Huron, final report on. I, 542
  Surveys and charts, with complete list of permanent and temporary bench marks .... I, 660, 665; IV, 2671, 2693
  Water levels .... I, 665; IV, 2678
  Water levels on east shore of Lake Michigan, variations in .... I, 498
Great Pedee River, S. C., improvement of .... I, 245; II, 1120
Great Salt Pond, Block Island, R. I., improvement of .... I, 102, 817
Great Sodus Bay, N. Y., improvement of harbor .... I, 568; III, 2155
Great South Bay, N. Y., improvement of .... I, 134, 875
Greenbay Harbor, Fox River, Wis.:
  Harbor lines .... I, 640; II, 1884
  Improvement of .... I, 477; II, 1839
Greene, Marion A. (schooner), removal of wreck of .... I, 228; II, 1088
Green Jacket shoal, Providence River, R. I., removal of .... I, 96, 803
Greenleaf Bend, Mississippi River, Ill., prevention of break into Cache River .... I, 392; II, 1455
Green River, Ky.:
  Improvement above mouth of Big Barren River .... I, 461; II, 1775
  Operating and care of locks and dams .... I, 461; II, 1776
Green Run Inlet life-saving station, Md., removal of wreck .... I, 194; 1023
Greensboro, N. C., monuments to Generals Nash and Davidson in Guilford battle grounds near .... I, 676; IV, 2939
Greenville Harbor, Miss. (*see* Mississippi River Commission) .... I, 639; S., 3, 40
Greenwich Harbor, Conn., improvement of .... I, 121, 851
Grounds, public buildings and, District of Columbia .... I, 658; IV, 2517
Guam Island, defenses of .... I, 8, 9, 14, 17
Guilford battle grounds, N. C., monuments to Generals Nash and Davidson .... I, 676; IV, 2939
Gulfport, Miss., improvement of channel to Ship Island Harbor .... I, 320; II, 1266
Gulf States:
  Removal of water hyacinths from Florida waters, including report on experiments made .... I, 279; II, 1184; IV, 2433
  Removal of water hyacinths from Louisiana waters .... I, 343; II, 1312
  Removal of water hyacinths from Texas waters .... I, 343
Gun and mortar batteries .... I, 9, 14, 17

Gut, the, South Bristol, Me., bridge across .... I, 652
Guttenberg, N. J., harbor lines in Hudson River .... I, 640, 905
Guyandot River, W. Va.:
  Bridge in Lincoln County .... I, 646
  Improvement of .... I, 448; II, 1741

H.

Hainesport, N. J., bridge across Rancocas River .... I, 647
Hall, Willie Lee (schooner), removal of wreck of .... I, 228; II, 1088
Hampton Roads, Va.:
  Defenses of .... I, 9
  Improvement of .... I, 221; II, 1076
  Improvement of approaches to Norfolk Harbor .... I, 219; II, 1074
  Removal of wreck .... I, 228; II, 1088
Handkerchief shoal, Mass., removal of wreck .... I, 103, 820
Harbor Beach, Mich.:
  Improvement of Sandbeach harbor of refuge .... I, 526; III, 1989
  Water levels at Sandbeach .... I, 665; IV, 2678
Harbor lines, establishment of .... I, 640
  Acushnet River, Mass., at New Bedford and Fairhaven .... I, 640, 820
  Albany, N. Y .... I, 640, 901
  Allegheny River, Pa .... I, 640; II, 1706, 1709
  Arthur Kill, N. Y. and N. J., recommendation for stone monuments to mark established lines .... I, 141
  Atlantic City bridge, Norfolk Harbor, Va .... I, 640; II, 1089
  Baltimore Harbor, Md., at Sparrow Point .... I, 640; II, 1035
  Berrian Island, East River, N. Y .... I, 640, 891
  Brooklyn, N. Y., Newtown Creek .... I, 640, 898
  China Basin, San Francisco Harbor, Cal., north of .... I, 640; III, 2202
  Delaware River, between Edgemoor and Christiana River, Del .... I, 640, 981
  Duluth Harbor, Minn .... I, 640; II, 1825
  East River, N. Y., at North Brother Island, Lawrence Point, and Berrian Island, and between East Thirteenth and East Eighteenth streets, New York City .... I, 640, 888, 891, 895
  Edgemoor, Del .... I, 640, 981
  Elizabeth, Pa .... I, 640; II, 1698
  Elizabeth River, Va .... I, 640; II, 1089
  Fairhaven Harbor, Mass .... I, 640, 820
  Fort Lee to Guttenberg, N. J .... I, 640, 905
  Fox River, Wis .... I, 640; II, 1883, 1884
  Greenbay Harbor, Wis .... I, 640; II, 1884
  Guttenberg to Fort Lee, N. J .... I, 640, 905
  Hazelwood, Pa .... I, 640; II, 1702
  Hudson River at Albany, N. Y .... I, 640, 901
  Hudson River from Fort Lee to Guttenberg, N. J .... I, 640, 905
  Jacksonville, Fla .... I, 640; II, 1187
  Kill van Kull, N. Y., recommendation for stone monuments to mark established lines along Staten Island .... I, 141
  Lawrence Point, East River, N. Y .... I, 640, 891
  Lee, Fort, to Guttenberg, N. J .... I, 640, 905
  Lermonds Cove, Rockland Harbor, Me .... I, 640, 727
  Maumee River, Ohio .... I, 640; III, 2107
  Mission rock, San Francisco Harbor, Cal., north of .... I, 640; III, 2202
  Mississippi River, at St. Louis, Mo .... I, 640; II, 1455
  Mississippi River, at St. Paul, Minn .... I, 640; II, 1513
  Monongahela River, Pa .... I, 640; II, 1698, 1702, 1706
  New Bedford Harbor, Mass .... I, 640, 820
  Newbern, N. C .... I, 640; II, 1114
  Newtown Creek, N. Y., east branch .... I, 640, 898
  New York Harbor, East River, N. Y .... I, 640, 888, 891, 895
  New York Harbor, Hudson River from Fort Lee to Guttenberg, N. J .... I, 640, 905
  New York Harbor, Newtown Creek at Brooklyn, N. Y .... I, 640, 898
  Norfolk Harbor, Va .... I, 640; II, 1089
  North Brother Island, East River, N. Y .... I, 640, 888
  North (Hudson) River, from Fort Lee to Guttenberg, N. J .... I, 640, 905

Harbor lines, establishment of—Continued.
  Oshkosh, Wis .... I, 640; II, 1883
  Patapsco River at Sparrow Point, Md .... I, 640; II, 1033
  Pawtucket (Seekonk) River, R. I .... I, 640, 825
  Pittsburg Harbor, Pa .... I, 640; II, 1702, 1706, 1709
  Providence Harbor and River, R. I., including Pawtucket (Seekonk) River .... I, 640, 825
  Rockland Harbor, Me .... I, 640, 727
  St. Johns River, Fla .... I, 640; II, 1187
  St. Louis Harbor, Mo .... I, 640; II, 1455
  St. Paul Harbor, Minn .... I, 640; II, 1513
  San Francisco Harbor, Cal .... I, 640; III, 2202
  Seekonk (Pawtucket) River, R. I .... I, 640, 825
  Smith Creek, Norfolk Harbor, Va .... I, 640; II, 1089
  Sparrow Point, Patapsco River, Md .... I, 640; II, 1033
  Staten Island, N. Y., recommendation for stone monuments to mark established lines along .... I, 141
  Superior Lake, at Duluth, Minn .... I, 640; II, 1828
  Toledo Harbor, Ohio .... I, 640; III, 2107
  Trent River, N. C .... I, 640: II, 1114
  Wilson, Pa .... I, 640; II, 1698
Harbors and rivers. *See* Rivers and harbors.
Hardings Beach light, Chatham, Mass., removal of wreck .... I, 103, 820
Hargraves, R. & T. (schooner), removal of wreck of .... I, 194, 1026
Harlem River, N. Y., improvement of .... I, 132, 872
Harlowe Creek, N. C., improvement of waterway via .... I, 235; II, 1101
Harriman, Tenn., bridge across Emory River .... I, 643
Harris, Anna M. (schooner), removal of wreck of .... I, 218; II, 1071
Harrisburg, Tex., bridge across Brays Bayou .... I, 647, 648
Harris, Elsie M. (schooner), removal of wreck of .... I, 194, 1023
Hartford, Conn.:
  Bridge across Connecticut River at .... I, 644
  Improvement of Connecticut River below .... I, 107, 836
Hartford, W. Va., ice harbor (*see* Ohio River) .... I, 423; II, 1627
Harvesta chemical compound, use of .... I, 279, 343; II, 1184, 1312; IV, 2433
Hat Slough, Wash. (*see* Puget Sound) .... I, 625; III, 2328
Havre de Grace, Md., improvement of Susquehanna River .... I, 183, 1004
Hawaiian Islands:
  Defenses of .... I, 8, 9, 14, 17
  Improvement of Pearl Harbor .... I, 592; III, 2201
Hay Lake channel, St. Marys River, Mich.:
  Final report on survey .... I, 542
  Improvement of .... I, 537; III, 2027
  Improvement of channels in waters connecting Great Lakes .... I, 532; III, 2001
Hazelwood, Pa., harbor lines in Monongahela River .... I, 640; II, 1702
Helena Harbor, Ark. (*see* Mississippi River Commission) .... I, 639; S., 3, 40
Hell Gate, East River, N. Y., improvement of .... I, 131, 871
Hempstead, N. Y. (*see* Glencove Harbor) .... I, 129, 867
Hen and Chickens light-ship, Mass., removal of wreck .... I, 104, 820
Henry C. (barge), removal of wreck of .... I, 194, 1024
Henry, Cape, Va., defenses at .... I, 9
Herr Island, Allegheny River, Pa.:
  Bridge across back channel .... I, 649
  Lock and dam at .... I, 438, 439; II, 1680, 1683
Highway bridge across Potomac River at Washington, D. C., to replace Long Bridge .... I, 643, 653; IV, 2484
Hillsboro Bay and River, Fla., improvement of .... I, 285; II, 1200
Hiwassee River, Tenn., improvement of .... I, 422; II, 1622
Hoboken, N. J., removal of wreck .... I, 139, 887
Hockingport, Ohio, ice harbor in Ohio River .... I, 423; II, 1627
Hoffman Island, New York Harbor, N. Y., removal of wreck .... I, 145, 925
Holland Harbor, Mich., improvement of .... I, 506; III, 1948
Holmes River, Fla., improvement of .... I, 298; II, 1222
Holston River, Va. and Tenn., improvement of .... I, 423; II, 1624
Home City, Ohio, Lock and Dam 37, Ohio River .... I, 426; II, 1645
Homochitto River, Miss., improvement of .... I, 335; II, 1299
Honolulu Harbor, Hawaii, defenses of .... I, 8, 9, 14, 17

Hookton, Cal. (*see* Humboldt Harbor) ..... I, 591; III, 2199
Hopefield Bend, Mississippi River (*see* Mississippi River Commission) I, 639; S., 3, 40
Hoquarten Slough, Oreg. (*see* Tillamook Bay) ..... I, 601; III, 2216
Horn Island Harbor, Miss., improvement of ..... I, 315; II, 1258
Hospital Point, Norfolk Harbor, Va., removal of ..... I, 220; II, 1074
Housatonic River, Conn., improvement of ..... I, 114, 844
House Committee on Rivers and Harbors. *See* Committee, etc.
Houston, Tex., improvement of waterway to Galveston ..... I, 351; II, 1334
Houston, Beaumont and New Orleans Railroad Company, bridges of ..... I, 648
Howard University reservoir, Washington, D. C ..... I, 654, 655; IV, 2485, 2499
Hudson River, N. Y. and N. J.:
    See also New York City and Harbor.
    Albany, N. Y., harbor lines ..... I, 640, 901
    Fort Lee to Guttenberg, N. J., harbor lines ..... I, 640, 905
    Improvement of ..... I, 135, 877
    Peekskill Harbor, N. Y., improvement of ..... I, 137, 885
    Rondout Harbor, N. Y., improvement of ..... I, 137, 884
    Saugerties Harbor, N. Y., improvement of ..... I, 136, 883
    Wrecks, removal of ..... I, 139, 887, 888
Humboldt Harbor and Bay, Cal., improvement of ..... I, 591; III, 2199
Humptulips River, Wash., bridge across ..... I, 651
Huntington Harbor, N. Y., improvement of ..... I, 128, 866
Huron Harbor, Ohio, improvement of ..... I, 546; III, 2061
Huron Lake (*see also* Northern and Northwestern Lakes):
    Final report on survey of waterway to Lake Superior ..... I, 542
    Improvement of harbor of refuge at Sandbeach, Mich ..... I, 526; III, 1989
    Water levels ..... I, 665; IV, 2678
Hutchinson River (East Chester Creek), N. Y., improvement of ..... I, 127, 864
Hyacinths, water:
    Removal of, from Florida waters, including report on experiments made ..... I, 279; II, 1184; IV, 2433
    Removal of, from Louisiana waters ..... I, 343; II, 1312
    Removal of, from Texas waters ..... I, 343
Hyannis, Mass.:
    Improvement of harbor of refuge ..... I, 88, 788
    Removal of wreck in harbor ..... I, 103, 819
Hydraulic mining in California ..... I, 638; III, 2367
Hydraulics. *See* Gauging.
Hydrology. *See* Gauging.
Hyers Run, W. Va., bridge across Little Kanawha River ..... I, 649

I.

I and J streets waterway, Whatcom, Wash., bridge across ..... I, 645, 646
Ida May (canal boat), removal of wreck of ..... I, 194, 1023
Illinois and Mississippi Canal, Ill.:
    Construction of ..... I, 496; III, 1920
    Operating and care ..... I, 395; II, 1496
Illinois Central Railroad Company, bridge of ..... I, 645
Illinois River, Ill.:
    Bridge at Chillicothe ..... I, 647
    Improvement of ..... I, 495; III, 1915
    Operating and care of locks and dams ..... I, 496; III, 1917
    Survey for waterway from Lockport, Ill., to St. Louis, Mo ..... I, 494, 639; III, 1904; S., 7, 68, 167
Indiana Chute, Falls of Ohio River, improvement of ..... I, 452; II, 1763
Indian River, Fla., improvement of ..... I, 276; II, 1181
Indian River, Mich., bridge across ..... I, 648
Indian River Bay, Del., waterway via ..... I, 180, 1002
Indian River Inlet, Fla. (*see* Indian River) ..... I, 276; II, 1181
Inland waterways. *See* Canals *and* Waterways.
Inside routes. *See* Canals *and* Waterways.
Insley, Mary E. (schooner), removal of wreck of ..... I, 165, 971
Insular possessions:
    Defenses of ..... I, 8, 9, 14, 17
    Improvement of Manila Harbor and Pasig River ..... I, 670; IV, 2903, 2910, 2911
    Improvement of Pearl Harbor, Hawaii ..... I, 592; III, 2201

Insular possessions—Continued.
- Reconnaissances and explorations in, with technical features of engineer operations in the former department of North Philippines, and present department of Luzon .... I, 668, 669, 670; IV, 2478, 2903
- Service of officers of the Corps of Engineers abroad and in the field, with troops .... I, 24

International Commission, Permanent, of Congresses of Navigation .... I, 639
Ironton, Ohio:
- Bridge across Ohio River to Ashland, Ky .... I, 644
- Improvement of Ohio River .... I, 423; II, 1627

Island possessions. *See* Insular possessions.
Isle of Wight Bay, Md., improvement of waterway via .... I, 180, 1002
Isles of Shoals, Me., improvement of harbor at .... I, 55, 733
Istokpoga Creek, Fla. (*see* Kissimmee River) .... I, 281; II, 1193

J.

Jackson, Ky., bridge across North Fork, Kentucky River .... I, 645
Jackson, Lansing and Saginaw Railroad Company, bridge of .... I, 648
Jacksonville, Fla.:
- *See also* St. Johns River.
- Harbor lines in St. Johns River .... I, 640; II, 1187

James River, Va.:
- Improvement of .... I, 216; II, 1065
- Protection of Jamestown Island .... I, 218; II, 1071

Jamestown Island, James River, Va., protection of .... I, 218; II, 1071
Jefferson, Tex., waterway to Shreveport, La. (*see* Cypress Bayou) ... I, 365; II, 1372
Jekyl Creek, Ga., improvement of waterway via .... I, 269; II, 1166
Jersey Central Traction Company, bridge of .... I, 650
Johnsons Bayou, La., improvement of .... I, 343; II, 1311
Johnsons Creek or River, Conn. (*see* Bridgeport Harbor) .... I, 115, 846
J street waterway, Whatcom, Wash., bridge across .... I, 645, 646
Judith Point, R. I.:
- Construction of harbor of refuge, with report on easterly detached breakwater .... I, 99, 807, 809
- Improvement of pond entrance .... I, 100, 814

Jupiter Inlet, Fla. (*see* Indian River) .... I, 277; II, 1181
Justice, Department of. *See* Attorney-General.

K.

Kalamazoo River, Mich., improvement of .... I, 504; III, 1945
Kampsville lock and dam, Illinois River, Ill., operating and care ... I, 496; III, 1917
Kanawha River, W. Va.:
- Improvement of .... I, 444; II, 1721
- Operating and care of locks and dams .... I, 445; II, 1723

Kansas City Southern Railway Company, bridge of .... I, 646
Karquines Straits, Cal., channel to the Golden Gate (*see* San Pablo Bay) .... I, 583; III, 2189
Kenduskeag River, Me. (*see* Penobscot River) .... I, 43, 717
Kennebec River, Me.:
- Defenses of, including report on telephone booths and damp-proofing .... I, 9; IV, 2371
- Improvement of .... I, 50, 724

Kennebunk River, Me., improvement of .... I, 55
Kennerdell, Pa., bridge across Allegheny River .... I, 647
Kenosha Harbor, Wis., improvement of .... I, 487; II, 1863
Kentucky Lumber and Veneer Company, bridge of .... I, 645
Kentucky, River, Ky.:
- Bridge across North Fork below Jackson .... I, 645
- Improvement of .... I, 450; II, 1748
- Operating and care of locks and dams .... I, 451; II, 1753

Keokuk, Iowa. *See* Mississippi River.
Kerrs Run, Ohio, ice harbor in Ohio River .... I, 423; II, 1627
Kewaunee Harbor, Wis., improvement of .... I, 481; II, 1848

Keweenaw Bay, Mich.:
Waterway to Lake Superior, improvement and care.......... I, 471, 472; II, 1815
Waterway to Lake Superior, removal of wreck .... I, 475; II, 1827
Keyport Harbor, N. J., improvement of.................................... I, 151, 939
Key West Harbor, Fla.:
Defenses of, including report on damp-proofing .... I, 9; IV, 2413
Improvement of, including dredge construction.............. I, 278, 980; II, 1183
Removal of wrecks .... I, 281; II, 1187
Kill van Kull, N. Y. and N. J.:
Improvement of Staten Island-New Jersey channel .... I, 148, 932
Recommendation for stone monuments to mark established harbor lines along Staten Island.. I, 141
Kingston Bay, Mass. (*see* Duxbury Harbor) .... I, 85, 781
Kingston, R. I.:
Construction of Point Judith harbor of refuge, with report on easterly detached breakwater.. I, 99, 807, 809
Improvement of entrance to Point Judith Pond........................ I, 100, 814
Kingsville, S. C., bridge across Wateree River at .... I, 646
Kinnickinnick River, Wis. (*see* Milwaukee Harbor) .... I, 485; II, 1857
Kissimmee Lake and River, Fla., improvement of................ I, 281; II, 1193
Knox and Lincoln Branch, Maine Central Railroad Company, bridge across Marsh River.. I, 649
Knoxville, Lafollette and Jellico Railroad Company, bridge of .... I, 644

L.

La Crosse Harbor, Wis., improvement of.......................... I, 396; II, 1500
Laffrinier, Ira (schooner), removal of wreck of .... I, 88, 785
Lafourche Basin levee board of Louisiana, lock and dam in Bayou Lafourche. I, 641
Lafourche Bayou, La.:
Construction of lock and dam by the Atchafalaya Basin and Lafourche Basin levee boards .... I, 641
Improvement of .... I, 330; II, 1287
Lagrange Bayou, Fla., improvement of.............................. I, 298; II, 1222
Lagrange lock and dam, Illinois River, Ill., operating and care ..... I, 496; III, 1917
Lakes, department of the, reconnaissances and explorations.......... I, 668; IV, 2899
Lakes Ditch, Atlantic City, N. J., bridge across .... I, 648
Lakes, Great. *See* Great Lakes.
Lake Washington Canal, Wash. *See* Puget Sound.
Lamb, L. L. (barge), removal of wreck of .... I, 556; III, 2106
Lambs, S. C., removal of wreck in Ashley River .... I, 257; II, 1140
Lamprey River, N. H. (*see* Cocheco River) .... I, 56, 734
L'Anguille River, Ark., improvement of .... I, 387; II, 1436
Larabee Landing, Lake Champlain, Vt., removal of wrecks near .... I, 73, 753
Larchmont Harbor, N. Y., improvement of .... I, 125, 860
La Trappe River, Md., improvement of.................................. I, 191, 1019
Lawrence Point, East River, N. Y., harbor lines .... I, 640, 891
Laws of 57th Congress, second session, affecting Corps of Engineers......... IV, 2943
Leaf River, Miss., improvement of.................................. I, 319; II, 1260
Leakesville, Miss., bridge across Chickasahay River .... I, 645
Leavenworth, Fort, Kans.:
Engineer depot at .... I, 21, 23, 703
Engineer troops at.. I, 5
Leech Lake, Minn.:
Construction of reservoir dam .... I, 398; II, 1528
Operating and care of reservoir dam .... I, 399; II, 1538
Lee County, Fla., bridge of .... I, 647
Lee, Fort, N. J., harbor lines in Hudson River .... I, 640, 905
Lee Slough, Apalachicola River, Fla., improvement of .... I, 292; II, 1212
Legislation of 57th Congress, second session, affecting Corps of Engineers .. IV, 2943
Leipsic River, Del., removal of wreck.................................. I, 194, 1025
Lemon Creek, N. Y. (*see* Staten Island-New Jersey channel)............. I, 148, 933
Leonardtown Harbor, Md. (*see* Breton Bay)................ I, 201; II, 1044, 1045
Leon County, Fla., bridge of.. I, 649
Lermonds Cove, Rockland Harbor, Me., harbor lines .... I, 640, 727
Levels, water. *See* water-level observations.

Levisa Fork, Big Sandy River, Ky.:
  Bridge near Whitehouse ..... i, 647
  Improvement of ..... i, 448; ii, 1742
Lewes, Del.:
  Improvement of waterway to Chincoteague Bay, Va ..... i, 180, 1002
  Iron pier in Delaware Bay near, maintenance and repair of ..... i, 163, 968
Lewis and Clark River, Oreg., bridge across ..... i, 649
Lewis River, Wash., improvement of ..... i, 618; iii, 2319
Lichtenfels Bros. (barge), removal of wreck of ..... i, 145, 924
Lincoln, Abraham, proposed monument to ..... i, 658; iv, 2565
Lincoln County, W. Va., bridge of ..... i, 646
Little Assawaman Bay, Del., waterway via ..... i, 180, 1002
Little Calumet River, Ill., bridge at Chicago ..... i, 647
Little Creek, Del., removal of wrecks ..... i, 194, 1023
Little D'Arbonne Bayou, La. (*see* D'Arbonne Bayou) ..... i, 368, 370; ii, 1379
Little Duck Creek (Leipsic River), Del., removal of wreck ..... i, 194, 1025
Littlefalls, Minn., bridge of city of, across Mississippi River ..... i, 642
Little Harbor, N. H., improvement of harbor of refuge ..... i, 58, 736
Little Kanawha Railroad Company, bridges of ..... i, 650
Little Kanawha River, W. Va.:
  Bridge at Hyers Run ..... i, 649
  Bridges in Wirt, Calhoun, Gilmer, and Braxton counties ..... i, 650
  Improvement of ..... i, 443; ii, 1718
  Operating and care of lock and dam ..... i, 444; ii, 1719
Little Mud River, Ga., improvement of waterway via ..... i, 269; ii, 1166
Little Myro (schooner), removal of wreck of ..... i, 194, 1024
Little Narragansett Bay, R. I. and Conn. (*see* Pawcatuck River) ..... i, 104, 831
Little Pedee River, S. C., improvement of ..... i, 244; ii, 1119
Little Pigeon River, Tenn., improvement of ..... i, 421; ii, 1616
Little River, Ark., bridge near White Cliffs ..... i, 646
Little River, La. (part of Red River), improvement of ..... i, 361; ii, 1363
Little River, La. (tributary of Red River), bridge near Simmons Ferry ..... i, 650
Little Sarasota Bay, Fla., improvement of ..... i, 284; ii, 1197
Little Sodus Bay, N. Y., improvement of harbor ..... i, 569; iii, 2157
Little Tallahatchie River, Miss. (*see* Tallahatchie River) ..... i, 373; ii, 1396
Livingston (schooner), removal of wreck of ..... i, 271; ii, 1171
Lockport, Ill., survey for waterway to St. Louis, Mo. i, 494, 639; iii, 1904; S., 7, 68, 167
Locks. *See* Canals *and* Waterways.
Lockwood (steamer), removal of wreck of ..... i, 556; iii, 2106
Lone Tree Point, Cal. (*see* San Pablo Bay) ..... i, 583; iii, 2189
Long Bridge, Potomac River, Washington, D. C., highway bridge to replace ..... i, 643, 653; iv, 2484
Long Island Sound, defenses of eastern entrance, including report on dampproofing ..... i, 9; iv, 2387
Long Sault Island, St. Lawrence River, N. Y., improvement at head of ..... i, 574; iii, 2168
Long Tom River, Oreg., improvement of ..... i, 609; iii, 2257
Lorain Harbor, Ohio:
  Bridge across Black River ..... i, 645
  Improvement of ..... i, 547; iii, 2066
  Removal of wreck ..... i, 556; iii, 2104
Louis Bayou, La., bridge across ..... i, 646
Louisiana, State of:
  Atchafalaya Basin and Lafourche Basin levee boards' lock and dam in Bayou Lafourche ..... i, 641
  Removal of water hyacinths from waters in, including report on experiments made in the Florida district ..... i, 343; ii, 1312; iv, 2433
  Rice Irrigation and Improvement Association's lock and dam in Mermentau River ..... i, 641
Louisiana and Arkansas Railroad Company, bridge of ..... i, 650
Louisiana Western Railroad, bridge across Calcasieu River, La ..... i, 648
Louisville and Portland Canal, Ky.:
  Enlargement of ..... i, 452; ii, 1763
  Operating and care ..... i, 455; ii, 1765
Loutre, Pass a, Mississippi River, La.:
  Closing crevasse in ..... i, 324; ii, 1275
  Constructing sill across ..... i, 325; ii, 1276

Lower Machodoc Creek, Va., improvement of .... I, 206; II, 1055
Lubec channel, Me., improvement of .... I, 37, 712
Ludington Harbor, Mich., improvement of .... I, 514; III, 1966
Luling, Chas. (schooner), removal of wreck of .... III, 2047
Lumberton Branch, Rancocas River, N. J., improvement of .... I, 166, 984
Luzon, department of, reconnaissances and explorations, including technical details of engineer operations .... I, 667, 669; IV, 2478, 2903
Lynn Harbor, Mass.:
  Bridge across Saugus River to Revere .... I, 650
  Improvement of .... I, 73, 759

M.

McClellan statue, Washington, D. C .... I, 658; IV, 2517
McClellanville, S. C., improvement of waterway to Charleston, with estimates of cost .... I, 252; II, 1132
McKees Rocks, Pa., bridge across Ohio River to Allegheny .... I, 644
Mackinac Straits, Mich., removal of wreck in .... I, 542; III, 2046
McKinley, Fort William, Manila Bay, P. I .... IV, 2481, 2907
Maçon Bayou, La., improvement of .... I, 368, 370; II, 1379
Maine Central Railroad Company, bridge of .... I, 649
Maine, defenses of coast, including report on telephone booths and dampproofing .... I, 9; IV, 2371
Main Ship channel, New York Harbor, N. Y.:
  Improvement of .... I, 139, 909
  Removal of wrecks .... I, 145, 924, 925
Malden River, Mass.:
  Bridge between Everett and Medford .... I, 650
  Improvement of .... I, 75, 761
Mall, the, Washington, D. C .... I, 658; IV, 2517
Mamaroneck Harbor, N. Y., improvement of .... I, 124, 859
Manasquan River, N. J., improvement of .... I, 157, 953
Manatee River, Fla.:
  Bridge at Craigs Point .... I, 643
  Improvement of .... I, 287; II, 1202
Manchac Bayou, La., improvement of .... I, 338; II, 1305
Manchac Pass, La., bridge in St. John the Baptist Parish .... I, 645
Manchester Harbor, Mass., improvement of .... I, 67, 745
Manila Bay and Harbor, P. I.:
  Defenses of .... I, 8, 9, 14, 17
  Improvement of .... I, 670; IV, 2903, 2910
  Reconnaissances and explorations in the former department of North Philippines, and present department of Luzon, with technical details of engineer operations .... I, 668, 669; IV, 2478, 2903
Manisees (U. S. steamer), removal of wrecks and other obstructions by .... I, 145, 925
Manistee Harbor, Mich., improvement of .... I, 516; III, 1970
Manitowoc Harbor and River, Wis.:
  Alleged shoal in Lake Michigan, south of .... I, 665; IV, 2883
  Improvement of .... I, 482; II, 1851
  Survey of .... I, 483; II, 1880
Manokin River, Md., improvement of .... I, 193, 1022
Manson, Agnes E. (schooner), removal of wreck of .... I, 103, 820
Mantua Creek, N. J., improvement of .... I, 168, 987
Maps:
  Land within flats of Anacostia River, D. C .... I, 36
  Military and other .... I, 667, 673; IV, 2478, 2899
  Northern and Northwestern Lakes .... I, 660, 665; IV, 2671
Marblehead Harbor, Mass.:
  Repair of sea wall .... I, 68, 747
  Survey for breakwater .... I, 69, 753
Marcushook, Pa., improvement of ice harbor .... I, 166, 984
Marine City, Mich., removal of wreck near .... III, 2047
Marinette, Wis. (*see* Menominee River) .... I, 475; II, 1834
Marion County, W. Va., bridge of .... I, 651
Market Street Elevated Passenger Railway Company, bridge of .... I, 648

Marquette Bay and Harbor, Mich.:
  Construction of harbor of refuge in bay I, 474; II, 1823
  Improvement of harbor I, 473; II, 1820
  Water levels I, 665; IV, 2678
Marriot (schooner), removal of wreck of I, 103, 820
Marsh River, Me., bridge at Newcastle I, 649
Marthas Vineyard, Mass., improvement of Vineyard Haven Harbor I, 90, 791
Martin (schooner), removal of wreck of III, 2047
Massachusetts, State of:
  Bridge of, across Malden River between Everett and Medford I, 650
  Bridge of, across Saugus River between Revere and Lynn I, 650
Matanzas River, Fla. (*see* St. Augustine Harbor) I, 275; II, 1181
Matawan Creek, N. J., improvement of I, 152, 941
Mathews, Dora (schooner), removal of wreck of I, 103, 820
Mattaponi River, Va., improvement of I, 214; II, 1063
Maumee Bay and River, Ohio:
  Harbor lines in river at Toledo I, 640; III, 2107
  Improvement of Toledo Harbor, including dredge construction I, 542, 979; III, 2049
  Removal of wreck in bay I, 557; III, 2106
May, Ida (canal boat), removal of wreck of I, 194, 1023
Medford, Mass., bridge across Malden River to Everett I, 650
Meerwald, Mary W. (sloop), removal of wreck of I, 165, 971
Memorials, statues, etc.:
  In public grounds, Washington, D. C I, 658; IV, 2517
  Memorial Bridge, Washington, D. C I, 653; IV, 2484
  Monuments to Gens. Francis Nash and William Lee Davidson I, 676; IV, 2939
Memphis Harbor, Tenn. (*see* Mississippi River Commission) I, 639; S., 3, 40
Memphis, Helena and Louisiana Railway Company:
  Bridge of, across St. Francis River, Ark I, 644
  Bridges of, across White and Arkansas rivers, Ark I, 643
Menekaunee, Wis. (*see* Menominee River) I, 475; II, 1834
Menominee Harbor and River, Mich. and Wis., improvement of I, 475; II, 1834
Menominee River, Milwaukee, Wis.:
  Bridges at West Water street I, 649
  Improvement of Milwaukee Harbor I, 485; II, 1857
Mercer, Gen. Hugh, monument to I, 658; IV, 2517
Mermentau River, La.:
  Construction of lock and dam by the Rice Irrigation and Improvement Association I, 641
  Improvement of, including tributaries I, 340; II, 1308
Merrimac River, Mass.:
  Improvement of I, 60, 738
  Improvement of Newburyport Harbor I, 59, 737
Methods, engineering, technical details of. *See* Technical details.
Metropolitan Park Commission of Massachusetts, bridge of I, 650
Metuchen, N. J., removal of wreck in Raritan River I, 159, 955
Mexico, Gulf of:
  Removal of water hyacinths from Florida tributaries, including report on experiments made I, 279; II, 1184; IV, 2433
  Removal of water hyacinths from Louisiana tributaries I, 343; II, 1312
  Removal of water hyacinths from Texas tributaries I, 343
Miami Harbor and River, Fla.:
  Bridge of Dade County at Avenue D I, 646
  Bridge of Florida East Coast Railway Company I, 648
  Improvement of Biscayne Bay I, 277; II, 1182
Mianus River, Conn., improvement of I, 122, 854
Michigan Central Railroad Company:
  Bridge of, across Indian River, Mich I, 648
  Bridge of, across Little Calumet River, Ill I, 647
Michigan City, Ind.:
  Improvement of inner harbor I, 498; III, 1931
  Improvement of outer harbor I, 498, 499; III, 1931
Michigan Lake (*see also* Northern and Northwestern Lakes):
  Alleged shoal south of Manitowoc Harbor, Wis I, 665; IV, 2883
  Canal to Sturgeon Bay, improvement of, including harbor of refuge I, 478; II, 1841

Michigan Lake—Continued.
  Canal to Sturgeon Bay, operating and care ... I, 480; II, 1846
  Dredge boat for harbors on eastern shore ... I, 498, 979
  Reef off Wind Point, near Racine Harbor, Wis ... I, 665; IV, 2883
  Water levels ... I, 665; IV, 2678
  Water levels on east shore, variations in ... I, 498
Michigan Lake Superior Power Company's canal at Sault Ste. Marie, Mich ... I, 641
Middle Island light-house, Lake Erie, removal of wreck ... I, 556; III, 2103
Middle Neebish channel, St. Marys River, Mich., improvement of ... I, 537; III, 2027
Middleport, Ohio, ice pier (*see* Ohio River) ... I, 423; II, 1627
Milan, Ill.:
  Construction of canal around Rock River at ... I, 496; III, 1920
  Operating and care of canal around Rock River at ... I, 395; II, 1496
Milford Harbor, Conn., improvement of ... I, 112, 843
Milford Haven, Va., improvement of harbor at ... I, 213; II, 1062
Military reconnaissances and explorations, with report on technical features of engineer operations in the former department of North Philippines, and present department of Luzon ... I, 667; IV, 2478, 2903
Miller Bay, Lake Winnebago, Wis. (*see* Fox River) ... I, 489; II, 1866
Mill River, New Haven, Conn., improvement of ... I, 110, 839
Mill River, Stamford, Conn. (*see* Stamford) ... I, 120, 850
Milwaukee Bay, Harbor, and River, Wis.:
  Bridges across Menominee River at West Water street ... I, 649
  Improvement of ... I, 485; II, 1857
  Water levels ... I, 665; IV, 2678
Mindanao, department of, reconnaissances and explorations ... I, 667, 669; IV, 2903
Miner, Bertha (barge), removal of wreck of ... I, 139, 887
Mines, submarine ... I, 13, 15, 17
Minim Creek-Estherville Canal, S. C. (*see* Santee River) ... I, 248; II, 1127
Mining casemates ... I, 13, 15, 17
Mining, hydraulic, in California ... I, 638; III, 2367
Minneapolis, Minn.:
  See also Mississippi River.
  Bridge at Fifth avenue across slough at Boom Island, Mississippi River. I, 650
Minneapolis, Superior, St. Paul and Winnipeg Railway Company, bridge of. I, 643
Minnesota River, Minn.:
  Improvement of ... I, 401; II, 1542
  Survey of Big Stone Lake and Lake Traverse for reservoir dam ... I, 404; II, 1549
Mispillion River, Del., improvement of ... I, 178, 998
Mission rock, San Francisco Harbor, Cal., harbor lines north of ... I, 640; III, 2202
Mississippi River:
  Anoka, Minn., bridge at ... I, 643
  Beechridge, Ill., prevention of break at ... I, 392; II, 1455
  Boom Island, Minneapolis, Minn., bridge across slough at ... I, 650
  Brainerd to Grand Rapids, Minn., improvement from ... I, 398; II, 1528
  Caruthersville, Mo. (*see* Mississippi River Commission) ... I, 639; S., 3, 40
  Delta Point, La. (*see* Mississippi River Commission) ... I, 639; S., 3, 40
  Des Moines Rapids Canal, examination for enlargement of locks, with estimates of cost, and for dam at foot of rapids ... II, 1500
  Des Moines Rapids Canal and dry dock, operating and care ... I, 395; II, 1491
  Dredge and snag boats above Missouri River, operation of ... I, 393; II, 1463
  Dredge and snag boats below Missouri River, operation of ... I, 389; II, 1441
  Dredge boats for outlet of ... I, 325, 326, 973, 980
  Gauging, including principal tributaries ... I, 405, 639; II, 1549; S., 7, 8, 62, 97
  Grand Rapids to Brainerd, Minn., improvement from ... I, 398; II, 1528
  Greenleaf Bend, Ill., prevention of break into Cache River ... I, 392; II, 1455
  Greenville, Miss. (*see* Mississippi River Commission) ... I, 639; S., 3, 40
  Head of Passes to headwaters, surveys from ... I, 639; S., 3, 40
  Head of Passes to Ohio River, improvement, surveys, etc ... I, 639; S., 3, 40
  Helena, Ark. (*see* Mississippi River Commission) ... I, 639; S., 3, 40
  Hopefield Bend (*see* Mississippi River Commission) ... I, 639; S., 3, 40
  Illinois and Mississippi Canal, Ill., construction of ... I, 496; III, 1920
  Illinois and Mississippi Canal, Ill., operating and care ... I, 395; II, 1496
  La Crosse Harbor, Wis., improvement of ... I, 396; II, 1500
  Littlefalls, Minn., bridge of city of ... I, 642
  Loutre, Pass a, La., closing crevasse in ... I, 324; II, 1275
  Loutre, Pass a, La., constructing sill across ... I, 325; II, 1276
  Memphis, Tenn. (*see* Mississippi River Commission) ... I, 639; S., 3, 40
  Minneapolis, Minn., bridge at Boom Island ... I, 650

Mississippi River—Continued.
  Minneapolis, Minn., to St. Paul, improvement from I, 396; II, 1523
  Missouri River, above, operation of snag and dredge boats I, 393; II, 1463
  Missouri River, below, removal of snags and wrecks I, 389; II, 1441
  Missouri River to Ohio River, improvement from I, 390; II, 1445
  Missouri River to St. Paul, Minn., improvement from I, 393; II, 1468
  Natchez, Miss. (*see* Mississippi River Commission) I, 639; S., 3, 40
  New Orleans, La., defenses of, including report on damp-proofing I, 9; IV, 2415
  New Orleans, La., improvement at, by Mississippi River Commission I, 639; S., 3, 40
  Ohio River to Head of Passes, improvement, surveys, etc I, 639; S., 3, 40
  Ohio River to Missouri River, improvement from I, 390; II, 1445
  Outlet, improvement of I, 325, 973; II, 1276
  Pass a Loutre, La., closing crevasse in I, 324; II, 1275
  Pass a Loutre, La., constructing sill across I, 325; II, 1276
  Passes of, dredge boats for I, 325, 326, 973, 980; II, 1276, 1277
  Plaquemine Bayou, La., construction of lock I, 332; II, 1289
  Pokegama Falls, Minn., construction of reservoir dam I, 398; II, 1528
  Pokegama Falls, Minn., operating and care of reservoir dam I, 399; II, 1538
  Reservoir dams at headwaters, construction of I, 398; II, 1528
  Reservoir dams at headwaters, operating and care I, 399; II, 1538
  St. Louis, Mo., harbor lines I, 640; II, 1455
  St. Louis, Mo., to Lockport, Ill., survey for waterway I, 494, 639; III, 1904; S., 7, 68, 167
  St. Paul, Minn., gauging I, 405; II, 1549
  St. Paul, Minn., harbor lines I, 640; II, 1513
  St. Paul, Minn., to Minneapolis, improvement from I, 396; II, 1523
  St. Paul, Minn., to Missouri River, improvement from I, 393; II, 1468
  Snag and dredge boats above Missouri River, operation of I, 393; II, 1463
  Snags and wrecks below Missouri River, removal of I, 389; II, 1441
  South Pass, examinations and surveys I, 328; II, 1278
  South Pass, maintenance of channel I, 328; II, 1279
  Southwest Pass, improvement of, including dredge construction I, 326, 980; II, 1277
  Vicksburg Harbor, Miss., improvement of I, 370; II, 1385
  Vidalia, La. (*see* Mississippi River Commission) I, 639; S., 3, 40
  Water-level observations on, including tributaries. I, 405, 639; II, 1549; S., 7, 8, 62, 97
  Wrecks, etc., above Missouri River, removal of I, 393; II, 1463
  Wrecks, etc., below Missouri River, removal of I, 389; II, 1441
Mississippi River Commission:
  Improvement of Mississippi River I, 639; S., 3, 40
  Survey for waterway from Lockport, Ill., to St. Louis, Mo I, 494, 639; III, 1904; S., 7, 68, 167
Mississippi Sound, Miss.:
  Improvement of Gulfport-Ship Island Harbor channel I, 320; II, 1266
  Improvement of Horn Island Harbor I, 315; II, 1258
Missouri, department of the, reconnaissances and explorations I, 668, 671; IV, 2914
Missouri River:
  Bridge between Cass County, Nebr., and Mills County, Iowa I, 644
  Bridge between Council Bluffs, Iowa, and East Omaha, Nebr I, 642
  Improvement of, with technical details concerning dike and revetment construction I, 405; II, 1551; IV, 2437
Mobile Harbor and River, Ala.:
  Defenses of, including report on damp-proofing I, 9; IV, 2414
  Improvement of I, 307; II, 1237
  Removal of sunken pontons in river I, 324; II, 1272
Moccasin River (Contentnia Creek), N. C., improvement of I, 232; II, 1096
Mokelumne River, Cal.:
  Bridge near mouth of Snodgrass Slough I, 646
  Improvement of I, 586; III, 2193
Monomoy Point, Mass., removal of wrecks off I, 103, 819, 820
Monongahela River, W. Va. and Pa.:
  Bridge at Fairmont, W. Va I, 651
  Harbor lines from Wilson to Elizabeth, at Hazelwood, and below Smithfield Street Bridge, Pittsburg, Pa I, 640; II, 1698, 1702, 1706
  Improvement at Locks 2, 3, and 6 I, 429; II, 1658
  Improvement of, between Morgantown and Fairmont, W. Va I, 427; II, 1652

Monongahela River, W. Va. and Pa.—Continued.
  Improvement of Pittsburg Harbor .... I, 432; II, 1667
  Operating and care of locks and dams .... I, 431; II, 1660
Monroe Harbor, Mich., improvement of .... I, 528; III, 1995
Monroe Lake, St. Johns River, Fla. (*see* Volusia bar) .... I, 274; II, 1179
Monuments, statues, etc.:
  In public grounds, Washington, D. C .... I, 658; IV, 2517
  Memorial Bridge, Washington, D. C .... I, 653; IV, 2484
  To Gens. Francis Nash and William Lee Davidson .... I, 676; IV, 2939
Morgan Canal, Tex.:
  Improvement of (*see* Galveston ship channel) .... I, 351; II, 1334
  Operating and care .... I, 353; II, 1337
Mormon channel, San Joaquin River, Cal.:
  Bridge at Stockton .... I, 648
  Improvement of .... I, 584, 585; III, 2190, 2193
Mortar batteries .... I, 9, 14, 17
Mosher, Amorette (schooner), removal of wreck of .... I, 556; III, 2105
Mosquito Creek Canal, S. C. (*see* Santee River) .... I, 248; II, 1127
Mound City, Ill. (*see* Ohio River) .... I, 423; II, 1627
Mount Desert, Bar Harbor, Me., construction of breakwater .... I, 39, 714
Mount Holly Branch, Rancocas River, N. J., improvement of .... I, 166, 964
Mount Hope Bay, Mass. (*see* Fall River Harbor) .... I, 97, 803
Mount Pleasant shore, Charleston, S. C., improvement at .... I, 253; II, 1134
Mount Rainier National Park, Wash., survey for road .... I, 37
Mud Lake, La. (*see* Mermentau River) .... I, 340; II, 1308
Mud River, Ga., improvement of waterway via .... I, 269; II, 1166
Mud River, S. C. (*see* Savannah-Beaufort waterway) .... I, 257; II, 1141
Murderkill River, Del., improvement of .... I, 176, 996
Muscle Shoals Canal, Tennessee River, Ala.:
  Construction of .... I, 417; II, 1594
  Operating and care .... I, 419; II, 1605
Muskegon Harbor, Mich., improvement of .... I, 510; III, 1958
Muskingum River, Ohio:
  Improvement of .... I, 446; II, 1731
  Operating and care of locks and dams .... I, 447; II, 1732
Myro, Little (schooner), removal of wreck of .... I, 194, 1024
Mystic River, Mass.:
  Improvement of .... I, 75, 761
  Improvement of, below mouth of Island End River .... I, 76, 763

N.

Nandua Creek, Va., improvement of .... I, 207; II, 1054
Nansemond River, Va., improvement of .... I, 222; II, 1078
Nanticoke River, Del. and Md., improvement of .... I, 192, 1021
Nantucket, Mass., construction of harbor of refuge at .... I, 89, 790
Nantucket Sound, Mass., removal of wrecks .... I, 103, 819, 820
Napa River, Cal., improvement of .... I, 590; III, 2198
Narragansett Bay, R. I.:
  Defenses of, including report on foundations, damp-proofing, and painting of concrete .... I, 9; IV, 2384
  Improvement of .... I, 95, 801
Narraguagus River, Me., improvement of .... I, 38, 713
Narrows of Lake Champlain, N. Y. and Vt.:
  Improvement of .... I, 72, 752
  Removal of wrecks .... I, 73, 753
Nasel River, Wash. (*see* Willapa River) .... I, 620; III, 2323
Nash, Gen. Francis, monument to .... I, 676; IV, 2939
Nashville Terminal Company, bridge of .... I, 643
Natalbany River, La. (*see* Tickfaw River) .... I, 338; II, 1303
Natchez Bay, La. (*see* Bayou Plaquemine) .... I, 332; II, 1289, 1312
Natchez Harbor, Miss. (*see* Mississippi River Commission) .... I, 639; S., 3, 40
National parks. *See* Parks.
Nauset Harbor, Mass., removal of wreck .... I, 88, 785
Navesink River, N. J. (*see* Shrewsbury River) .... I, 155, 950
Navigable waters. *See* Bridges, Rivers and harbors, *and* Wrecks.
Navigation, Congresses of, Permanent International Commission .... I, 639
Neches River, Tex., improvement of .... I, 344; II, 1314
Neebish channels, St. Marys River, Mich., improvement of .... I, 537; III, 2027

- Negro Cut, Indian River Inlet, Fla. (*see* Indian River) .... I, 276; II, 1181
- Neshaminy Creek, Pa., bridge near Croydon .... I, 646
- Nettie (sloop), removal of wreck of .... I, 194, 1023
- Neuse River, N. C.:
  - Improvement of .... I, 223; II, 1097
  - Improvement of waterway between Newbern and Beaufort .... I, 235; II, 1101
- Newark, N. J.:
  - Improvement of Passaic River .... I, 145, 927
  - Removal of wreck in Passaic River .... I, 159, 955
- Newark Bay, N. J.:
  - Improvement of (*see* Arthur Kill) .... I, 148, 932
  - Improvement of (*see* Passaic River) .... I, 145, 927
  - Removal of wrecks .... I, 158, 159, 954, 955
- New Bedford Harbor, Mass.:
  - Defenses of .... I, 9
  - Harbor lines .... I, 640, 820
  - Improvement of .... I, 92, 794
- Newbern, N. C.:
  - Harbor lines in Trent River .... I, 640; II, 1114
  - Improvement of Neuse River .... I, 233; II, 1097
  - Improvement of Trent River .... I, 234; II, 1099
  - Improvement of waterway to Beaufort, N. C .... I, 235; II, 1101
- Newburgh and South Shore Railway Company, bridge of .... I, 650
- Newburyport Harbor, Mass., improvement of .... I, 59, 737
- Newcastle, Me., bridge across Marsh River .... I, 649
- New Haven Harbor, Conn.:
  - Bridge across West River at Kimberly avenue .... I, 651
  - Construction of breakwaters .... I, 112, 842
  - Improvement of, by dredging .... I, 110, 839
- New Jersey-Staten Island channel:
  - Improvement of .... I, 147, 932
  - Removal of wrecks in Arthur Kill .... I, 158, 159, 955, 956
- New London Harbor, Conn.:
  - Bridge across Smiths Cove, Thames River .... I, 652
  - Improvement of .... I, 105, 833
- New London Northern Railroad Company, bridge of .... I, 652
- New Orleans Harbor, La.:
  - Defenses of, including report on damp-proofing .... I, 9; IV, 2415
  - Improvement of (*see* Mississippi River Commission) .... I, 639; S., 3, 40
- Newport Bridge, Belt and Terminal Railway Company, bridge of .... I, 642
- Newport Harbor, Ark., bridge across White River .... I, 642
- Newport Harbor, R. I., improvement of .... I, 98, 805
- Newport News Point, Hampton Roads, Va., removal of wreck .... I, 228; II, 1088
- Newport River, N. C.:
  - Improvement of Beaufort Harbor .... I, 236; II, 1102
  - Improvement of waterway between Beaufort and New River .... I, 236; II, 1103
  - Improvement of waterway between Newbern and Beaufort .... I, 235; II, 1101
- New River, N. C.:
  - Improvement of .... I, 237; II, 1104
  - Improvement of waterway to Beaufort .... I, 236; II, 1103
- New Rochelle, N. Y. (*see* Echo Bay Harbor) .... I, 126, 861
- New Shoreham, Block Island, R. I.:
  - Construction of harbor of refuge .... I, 101, 815
  - Improvement of Great Salt Pond .... I, 102, 817
- Newtown Creek, N. Y.:
  - Harbor lines in east branch at Brooklyn .... I, 640, 898
  - Improvement of .... I, 133, 873
- New Whatcom Harbor, Wash.:
  - Bridge across I and J streets waterway .... I, 645, 646
  - Bridge across Whatcom Creek waterway .... I, 647
  - Improvement of .... I, 634; III, 2337
- New York, Chicago and St. Louis Railroad Company:
  - Bridge of, across Black River, Ohio .... I, 645
  - Bridge of, across Calumet River, Ill .... I, 643, 644
- New York City and Harbor, N. Y.:
  - Ambrose channel, improvement of, including dredge construction. I, 139, 909, 979
  - Arthur Kill, improvement of .... I, 147, 932

New York City and Harbor, N. Y.—Continued.
  Arthur Kill, recommendation for stone monuments to mark established harbor lines .... I, 141
  Arthur Kill, removal of wrecks.... I, 158, 159, 955, 956
  Battery, the, removal of shoal off Pier A .... I, 140, 911
  Bay Ridge channel, improvement of .... I, 142, 915
  Bayside channel, improvement of.... I, 139, 909
  Berrian Island, East River, harbor lines .... I, 640, 891
  Bronx River, improvement of .... I, 126, 862
  Bronx River, removal of wrecks.... I, 138, 139, 887
  Buttermilk channel, improvement of .... I, 143, 917
  Buttermilk channel, removal of obstruction .... I, 145, 925
  Defenses of, including report on damp-proofing .... I, 9, 14, 16; IV, 2390
  East (Ambrose) channel, improvement of.... I, 139, 909, 979
  East Chester Bay, bridge in Pelham Bay Park.... I, 650
  East Chester Creek, improvement of.... I, 126, 864
  East River, harbor lines at North Brother Island, Lawrence Point, and Berrian Island, and between East Thirteenth and East Eighteenth streets .... I, 640, 888, 891, 895
  East River, improvement of .... I, 131, 871
  East River, removal of wreck.... I, 139, 887
  Engineer depot.... I, 21, 23, 705
  Flushing Bay, improvement of .... I, 129, 868
  Fort Lee, N. J., harbor lines in Hudson River to Guttenberg .... I, 640, 905
  Fort Totten, building for School of Submarine Defense.... I, 13, 16
  Gedney channel, improvement of.... I, 139, 909
  Governors Island, enlargement of.... I, 144, 920
  Gowanus Bay and Canal, improvement of .... I, 142, 915
  Gowanus Creek, removal of wreck .... I, 145, 924
  Gowanus Creek channel, improvement of .... I, 143, 919
  Harlem River, improvement of .... I, 132, 872
  Hell Gate, East River, improvement of .... I, 131, 871
  Hoffman Island, removal of wreck.... I, 145, 925
  Hudson River, harbor lines from Fort Lee to Guttenberg, N. J .... I, 640, 905
  Hudson River, removal of wreck near Hoboken, N. J.... I, 139, 887
  Hudson River, removal of reef off Pier A, North River.... I, 140, 911
  Improvement of, including dredge construction.... I, 139, 909, 979
  Kill van Kull, improvement of Staten Island-New Jersey channel .... I, 148, 932
  Kill van Kull, recommendation for stone monuments to mark established harbor lines along Staten Island .... I, 141
  Lawrence Point, East River, harbor lines.... I, 640, 891
  Lee, Fort, N. J., harbor lines in Hudson River to Guttenberg.... I, 640, 905
  Lemon Creek (*see* Staten Island-New Jersey channel).... I, 148, 933
  Main Ship channel, improvement of .... I, 139, 909
  Main Ship channel, removal of wrecks.... I, 145, 924, 925
  Newark Bay, improvement of (*see* Passaic River) .... I, 145, 927
  New Jersey-Staten Island channel, improvement of.... I, 148, 932
  Newtown Creek, harbor lines in east branch, at Brooklyn.... I, 640, 898
  Newtown Creek, improvement of.... I, 133, 873
  North Brother Island, East River, harbor lines.... I, 640, 888
  North (Hudson) River, harbor lines from Fort Lee to Guttenberg, N. J. I, 640, 905
  North (Hudson) River, removal of reef off Pier A .... I, 140, 911
  North (Hudson) River, removal of wrecks .... I, 139, 887
  Pelham Bay Park, bridge across East Chester Bay.... I, 650
  Red Hook channel, improvement of .... I, 142, 915
  Southwest Spit, removal of obstructions.... I, 145, 925
  Spuyten Duyvil Creek (*see* Harlem River).... I, 132, 872
  Staten Island-New Jersey channel, improvement of .... I, 148, 932
  Staten Island Sound (Arthur Kill), improvement of.... I, 147, 932
  Staten Island Sound (Arthur Kill), removal of wrecks .... I, 158, 159, 955, 956
  Staten Island water front, recommendation for stone monuments to mark established harbor lines .... I, 141
  Supervision of.... I, 637; III, 2359
  Tompkinsville, removal of wreck off .... I, 145, 924
  Totten, Fort, building for School of Submarine Defense .... I, 13, 16
Niagara River, N. Y.:
  Buffalo Harbor, improvement of .... I, 559; III, 2126
  Erie Basin and Black Rock Harbor, improvement of Buffalo entrance .... I, 562; III, 2143

Niagara River, N. Y.—Continued.
  Erie Basin and Black Rock Harbor, improvement of Lake Erie entrance I, 562; III, 2142
  North Tonawanda to Lake Erie, including Tonawanda Harbor, improvement from I, 563; III, 2144
  Surveys, etc. (*see* Northern and Northwestern Lakes) I, 660; IV, 2671
Nomini Creek, Va., improvement of I, 209; II, 1057
Nooksak River, Wash. (*see* Puget Sound) I, 625; III, 2328
Norfolk Harbor, Va.:
  Harbor lines in Smith Creek and Elizabeth River I, 640; II, 1089
  Defenses of Hampton Roads I, 14
  Improvement of, and its approaches, including Hospital Point I, 219; II, 1074
  Improvement of waterway to Albemarle Sound, via Currituck Sound I, 226; II, 1084
  Improvement of waterway to sounds of North Carolina, via Pasquotank River I, 225; II, 1083
  Improvement of Western Branch, Elizabeth River I, 220; II, 1076
North Branch, Chicago River, Ill. *See* Chicago Harbor and River.
North Brother Island, East River, N. Y., harbor lines I, 640, 888
North Carolina Cut, N. C., improvement of waterway via I, 226; II, 1084
North Carolina, State of:
  Defenses of coast, including report on damp-proofing and on use of paint made of coal tar and kerosene oil I, 9; IV, 2408
  Improvement of waterways from Norfolk, Va., to sounds of I, 225, 226; II, 1083, 1084
North Coeymans, N. Y., removal of wreck in Hudson River I, 139, 888
Northeast River, N. C., improvement of I, 238; II, 1105
Northern and Northwestern Lakes:
  Commercial statistics, Sault Ste. Marie canals, Mich I, 535; III, 2010, 2015
  Dredge boat for harbors on Lake Erie. *See* Dredge boats, etc.
  Dredge boat for harbors on eastern shore of Lake Michigan I, 498, 979
  Defenses of I, 8, 9
  Improvement of channels in waters connecting I, 532; III, 2001
  Outflow, rainfall, and evaporation in valley of I, 665; IV, 2855
  Survey of waters connecting lakes Superior and Huron, final report on I, 542
  Surveys and charts, with complete list of permanent and temporary bench marks I, 660, 665; IV, 2671, 2693
  Water levels I, 665; IV, 2678
  Water levels on east shore of Lake Michigan, variations in I, 498
Northern Pacific Railway Company:
  Bridge of, across Deschutes River, Wash I, 645
  Bridge of, across Humptulips River, Wash I, 651
  Bridge of, across Lake Pend Oreille, Idaho I, 646
  Bridge of, across right of way of Lake Washington Canal, Wash I, 645
North Fork, Kentucky River, Ky., bridge below Jackson I, 645
North Fork, Skagit River, Wash. (*see* Puget Sound) I, 625; III, 2328
North Hero Island channel, Lake Champlain, Vt., improvement of I, 69
North Landing River, Va. and N. C., improvement of waterway via I, 226; II, 1084
North Philippines, department of, reconnaissances and explorations, including technical features of engineer operations I, 666, 669; IV, 2478, 2903
North (Hudson) River, N. Y. *See* New York City and Harbor.
North (Tolomato) River, Fla. (*see* St. Augustine Harbor) I, 275; II, 1181
North River, N. C.:
  Improvement of waterway via I, 226; II, 1084
  Removal of wreck I, 228; II, 1088
North River, Wash. (*see* Willapa River) I, 620; III, 2323
North Tonawanda, N. Y. (*see* Tonawanda) I, 563; III, 2144
Norwalk Harbor, Conn., improvement of I, 118, 849

O.

Oak Creek, Wis. (*see* South Milwaukee Harbor) I, 486; II, 1860
Oakdene (steamer), removal of wreck I, 194, 1024
Oakland Harbor, Cal.:
  Bridge across San Leandro Bay between Alameda and Bay Farm Island I, 646
  Defenses of San Francisco, including report on construction methods, damp-proofing, and transportation of ordnance I, 9; IV, 2417
  Improvement of I, 582; III, 2186

Oak Orchard Harbor, N. Y., improvement of .... I, 565; III, 2149
Obion River, Tenn.:
    Bridge near Burnt Mills .... I, 646
    Improvement of .... I, 410; II, 1579
Occoquan Creek, Va., improvement of .... I, 205; II, 1051
Ocklawaha (Oklawaha) River, Fla., improvement of .... I, 275; II, 1180
Ocklockonee River, Fla.:
    Bridge in Leon County .... I, 649
    Bridge near Sopchoppy .... I, 652
Ocmulgee River, Ga., improvement of .... I, 266; II, 1161
Oconee River, Ga., improvement of .... I, 265; II, 1160
Oconto Harbor, Wis., improvement of, including report on project by the Board of Engineers for Rivers and Harbors .... I, 476; II, 1835, 1836
Ocracoke Inlet, N. C., improvement of .... I, 229; II, 1093
Office of the Chief of Engineers, officers on duty in .... I, 676
Officers, engineer, civilian assistants to .... I, 23
Officers of the Corps of Engineers. *See* Corps of Engineers.
Ogdensburg Harbor, N. Y., improvement of .... I, 573; III, 2165
Ohio River:
    Bridge between Allegheny and borough of McKees Rocks, Pa .... I, 644
    Bridge between Ironton, Ohio, and Ashland, Ky .... I, 644
    Bridge between Steubenville, Ohio, and Cross Creek Township, W. Va. .... I, 644
    Bridges impeding navigation, report upon .... I, 37
    Falls at Louisville, Ky., improvement of .... I, 452; II, 1763
    Gauging (*see* Mississippi River Commission) .... I, 639; S., 7, 8, 62, 97
    General improvement from Pittsburg to the mouth .... I, 423; II, 1627
    Ice piers .... I, 423; II, 1627
    Indiana Chute, Louisville, Ky., improvement of .... I, 452; II, 1763
    Lock and Dam 1, at Davis Island, Pa., operating and care .... I, 435; II, 1671
    Locks and Dams 2–7, construction of .... I, 435; II, 1672
    Locks and Dams 8, 11, 13, 18, 19, construction of .... I, 441; II, 1713
    Lock and Dam 37, construction of .... I, 426; II, 1645
    Louisville and Portland Canal, Ky., enlargement of .... I, 452; II, 1763
    Louisville and Portland Canal, Ky., operating and care .... I, 455; II, 1765
    Pittsburg Harbor, Pa., improvement of .... I, 432; II, 1667
    Pittsburg Harbor, Pa., Davis Island pool (No. 1), survey for increased depth and additional harbor facilities .... I, 434; II, 1688
    Snag boat, operation of .... I, 426; II, 1647
Okanogan River, Wash., improvement of .... I, 635; III, 2338
Oklawaha River, Fla., improvement of .... I, 275; II, 1180
Olcott Harbor, N. Y., improvement of .... I, 566; III, 2151
Old Tampa Bay, Fla. (*see* Tampa Bay) .... I, 284; II, 1198
Olympia Harbor, Wash.:
    Bridge across Deschutes River .... I, 645
    Improvement of .... I, 626; III, 2330
Omaha Bridge and Terminal Railway Company, bridge of .... I, 642
Omaha (East), Nebr., bridge across Missouri River to Council Bluffs, Iowa. I, 642
Ontario Lake (*see also* Northern and Northwestern Lakes):
    Removal of wreck off Braddock Point light station .... I, 575; III, 2169
    Water levels .... I, 665; IV, 2678
Ontonagon Harbor, Mich., improvement of .... I, 470; II, 1813
Oostenaula River, Ga., improvement of .... I, 303, 305; II, 1233
Orange, Conn., Kimberly avenue bridge across West River to New Haven. I, 651
Orange Mills flats, St. Johns River, Fla.:
    Improvement at and near .... I, 273; II, 1178
    Removal of water hyacinths in vicinity of, including report on experiments made .... I, 279; II, 1184; IV, 2433
Orange River, Fla., improvement of .... I, 282; II, 1194
Ordnance. *See* Fortifications.
Ordway rifle range .... I, 17, 686
Osage River, Mo., improvement of .... I, 408; II, 1568
Oshkosh, Wis.:
    Bridge across Fox River .... I, 645
    Harbor lines in Fox River .... I, 640; II, 1884
    Improvement of Fox River .... I, 489; II, 1866
Oswegatchie River, N. Y. (*see* Ogdensburg Harbor) .... I, 573; III, 2165

- Oswego Harbor, N. Y., improvement of ... I, 570; III, 2160
- Otter Creek, Vt., improvement of ... I, 71, 750
- Otter Tail Lake and River, Minn., survey of ... I, 404; II, 1548
- Ouachita River, Ark. and La.:
  - Bridge between Ashley and Union counties, Ark ... I, 643
  - Improvement of ... I, 366; II, 1373
- Outflow, rainfall, and evaporation in valley of Northern and Northwestern Lakes ... I, 665; IV, 2855
- Ozark and Cherokee Central Railway Company, bridge of ... I, 642

P.

- Pacific County, Wash., bridge of ... I, 647
- Pagan River, Va., improvement of ... I, 222; II, 1079
- Pamlico County, N. C., bridge of ... I, 652
- Pamlico River, N. C., improvement of ... I, 231; II, 1094
- Pamlico Sound, N. C., improvement of waterway to Norfolk, Va ... I, 225; II, 1083
- Pamunkey River, Va., improvement of ... I, 215; II, 1064
- Parks, public:
  - District of Columbia, improvement and care ... I, 658; IV, 2517
  - Mount Rainier National Park, Wash., survey for road ... I, 37
  - Yellowstone National Park, improvement, etc., with report giving technical details ... I, 666; IV, 2444, 2885
- Pascagoula River, Miss.:
  - Improvement above mouth of Dog River ... I, 317; II, 1260
  - Improvement below mouth of Dog River ... I, 315; II, 1258
- Pasig River, Philippine Islands, improvement of ... I, 670; IV, 2903, 2911
- Pasquotank River, N. C.:
  - Improvement of waterway via ... I, 225; II, 1083
  - Removal of cribs of logs ... I, 228; II, 1088
- Passaic, N. J.:
  - Improvement of Passaic River ... I, 145, 927
  - Removal of wreck in Passaic River ... I, 158, 954
- Passaic Bridge, N. J., removal of wreck in Passaic River ... I, 158, 954
- Passaic light-house, Newark Bay, N. J., removal of wreck ... I, 159, 955
- Passaic River, N. J.:
  - Improvement of ... I, 145, 927
  - Removal of wrecks ... I, 158, 159, 954, 955
- Pass a Loutre, Mississippi River, La.:
  - Closing crevasse in ... I, 324; II, 1275
  - Constructing sill across ... I, 325; II, 1276
- Pass Manchac, La., bridge in St. John the Baptist Parish ... I, 645
- Patapsco River, Md.:
  - Bridge at Spring Garden, Baltimore ... I, 649
  - Defenses of Baltimore, including report on damp-proofing ... I, 9; IV, 2400
  - Harbor lines at Sparrow Point ... I, 640; II, 1033
  - Improvement of, and channel to Baltimore ... I, 194; II, 1027
  - Improvement of channel to Curtis Bay ... I, 196; II, 1031
  - Improvement of harbor at southwest Baltimore (Spring Garden) . I, 197; II, 1031
  - Revised estimate of cost of increasing depth of channel to Baltimore. I, 195; II, 1032
- Patchogue River, N. Y., improvement of (*see* Great South Bay) ... I, 134, 875
- Patcong Creek, N. J., bridge at Steelmanville ... I, 651
- Patuxent River, Md., improvement of, including report on project by the Board of Engineers for Rivers and Harbors ... I, 203; II, 1047, 1048
- Pawcatuck River, R. I. and Conn., improvement of ... I, 104, 831
- Pawpaw River, Mich. (*see* St. Joseph Harbor) ... I, 501; III, 1937
- Pawtucket (Seekonk) River, R. I.:
  - Harbor lines at Providence ... I, 640, 825
  - Improvement of ... I, 95, 799
- Peace Creek, Fla. (*see* Charlotte Harbor) ... I, 282; II, 1194
- Pearl Harbor, Hawaii:
  - Defenses of ... I, 8, 9, 14, 17
  - Improvement of ... I, 592; III, 2201
- Pearl River, Miss.:
  - Improvement between Edinburg and Jackson ... I, 323; II, 1270
  - Improvement below Rockport ... I, 322; II, 1269

Pedee rivers, S. C.:
- Improvement of Little Pedee .... I, 244; II, 1119
- Improvement of Great Pedee .... I, 245; II, 1120

Peekskill Harbor, N. Y., improvement of .... I, 137, 885
Pelham Bay Park, N. Y., bridge across East Chester Bay .... I, 650
Pell (sloop), removal of wreck of .... I, 139, 887
Pender County, N. C., bridge of .... I, 648
Pend Oreille Lake, Idaho, bridge across .... I, 646
Pend Oreille River, Wash., improvement of .... I, 635; III, 2358
Pennsylvania Railroad Company:
- Bridge of .... I, 649
- Bridge of Philadelphia, Baltimore and Washington Railroad Company. I, 649, 650

Penobscot River, Me.:
- Defenses of, including report on telephone booths and damp-proofing .... I, 9; IV, 2371
- Improvement of .... I, 43, 717
- Improvement of Bucksport Harbor .... I, 45, 719

Pensacola Harbor, Fla.:
- Defenses of, including report on damp-proofing .... I, 9, 12; IV, 2413
- Improvement of, including dredge construction .... I, 299, 977; II, 1223

Pentwater Harbor, Mich., improvement of .... I, 512; III, 1962
Pequonnock River, Conn. (*see* Bridgeport Harbor) .... I, 115, 846
Pere Marquette Lake, Mich. (*see* Ludington Harbor) .... I, 514; III, 1966
Permanent International Commission of Congresses of Navigation .... I, 639
Petaluma Creek, Cal., improvement of .... I, 589; III, 2197
Petersburg, Va., diversion of Appomattox River at .... I, 224; II, 1080
Petoskey Harbor, Mich., improvement of .... I, 521; III, 1981
Philadelphia, Pa.:
- Bridge across Schuylkill River at Market street .... I, 648
- Defenses of Delaware River .... I, 9
- Improvement of Delaware River at .... I, 159, 957, 960
- Removal of wreck in Delaware River at .... I, 165, 971
- Removal of wreck in Schuylkill River at .... I, 194, 1024

Philadelphia, Baltimore and Washington Railroad Company, bridge of... I, 649, 650
Philadelphia, Bristol and Trenton Street Railway Company, bridge of .... I, 646
Philippine Islands:
- Defenses of .... I, 8, 9
- Improvement of Manila Harbor and Pasig River..... I, 670; IV, 2903, 2910, 2911
- Reconnaissances and explorations in, with technical features of engineer operations in the former department of North Philippines, and present department of Luzon .... I, 668, 669; IV, 2478, 2903
- Service of officers of the Corps of Engineers abroad and in the field, with troops .... I, 24

Philippines (North), department of, reconnaissances and explorations, including technical features of engineer operations ...... I, 666, 669; IV, 2478, 2903
Phillips, W. K. (steamer), removal of wreck of .... I, 417; II, 1589
Pierhead lines. *See* Harbor lines.
Pierre, S. Dak. (*see* Missouri River) .... I, 405; II, 1551
Pierre, Fort, S. Dak. (*see* Missouri River) .... I, 405; II, 1551
Pigeon Bayous, La., improvement of .... I, 332; II, 1289
Pike Creek, Wis. (*see* Kenosha Harbor) .... I, 487; II, 1863
Pine Island Sound, Fla. (*see* Charlotte Harbor) .... I, 282; II, 1194
Pine Lake and River (Charlevoix County), Mich. (*see* Charlevoix Harbor) .... I, 519; III, 1978
Pine River (St. Clair County), Mich., improvement of .... I, 530; III, 1997
Pine River, Minn.:
- Construction of reservoir dam .... I, 398; II, 1528
- Operating and care of reservoir dam .... I, 399; II, 1538

Pineville, La.:
- Bridge across Red River to Alexandria (Alexandria and Pineville Bridge Company) .... I, 644
- Bridge across Red River to Alexandria (Shreveport and Red River Valley Railway Company) .... I, 643

Pinole, Point, Cal. (*see* San Pablo Bay) .... I, 583; III, 2189
Pittsburg Harbor, Pa.:
- *See also* Allegheny, Monongahela, *and* Ohio rivers.
- Bridge across Allegheny River, to Allegheny (Union Bridge) .... I, 651

Pittsburg Harbor, Pa.—Continued.
  Bridge across Allegheny River at Brilliant Station .... I, 649
  Bridge across Allegheny River at Herr Island .... I, 649
  Harbor lines in Monongahela and Allegheny rivers... I, 640; II, 1702, 1706, 1709
  Improvement of .... I, 432; II, 1667
  Survey of Davis Island pool (No. 1), Ohio River, for increased depth and additional harbor facilities .... I, 434; II, 1688
Plantz, Laura E. (canal boat), removal of wreck of .... I, 159, 955
Plaquemine Bayou, La.:
  Improvement of .... I, 332; II, 1289
  Removal of water hyacinths, including report on experiments made in the Florida district .... I, 343; II, 1312; IV, 2433
Plattsburg Harbor, N. Y., improvement of .... I, 72, 751
Plattsmouth Pontoon Bridge Company, bridge of .... I, 644
Pleasant, Point, Me., bridge to Carlows Island .... I, 652
Pleasantville and Atlantic Turnpike or Plank Road Company, bridge of.... I, 647
Plymouth Harbor, Mass., improvement of .... I, 86, 782
Pocomoke River, Md., improvement of .... I, 189, 1015
Poge, Cape, light-house, Mass., removal of wreck .... I, 103, 819
Point Judith Harbor and Pond, R. I.:
  Construction of harbor of refuge, with report on easterly detached breakwater .... I, 99, 807, 809
  Improvement of pond entrance .... I, 100, 814
Point Pinole, Cal. (*see* San Pablo Bay) .... I, 583; III, 2189
Point Pleasant, Me., bridge to Carlows Island .... I, 652
Point Wilson, Cal. (*see* San Pablo Bay) .... I, 583; III, 2189
Pokegama Falls, Mississippi River, Minn.:
  Construction of reservoir dam .... I, 398; II, 1528
  Operating and care of reservior dam .... I, 399; II, 1538
Pollock Rip light-ship, Mass., removal of wreck .... I, 103, 819
Pomeroy, Ohio, ice harbor at Kerrs Run (*see* Ohio River) .... I, 423; II, 1627
Pomeroy Center, Ohio, ice pier (*see* Ohio River) .... I, 423; II, 1627
Ponchatoula River, La. (*see* Tickfaw River) .... I, 338; II, 1303
Pony Slough, Coos Bay, Oreg., improvement of .... I, 595; III, 2209
Popes Island, Va., removal of wreck .... I, 194, 1024
Porcupine Island, Bar Harbor, Me., construction of breakwater .... I, 39, 714
Portage Lake, Manistee County, Mich., improvement of harbor of refuge .... I, 517; III, 1973
Portage Lake and Lake Superior canals, Houghton County, Mich.:
  Improvement and care .... I, 471, 472; II, 1815
  Removal of wreck .... I, 475; II, 1827
Portage River, Houghton County, Mich., waterway via .... I, 471, 472; II, 1815
Portage River, Ohio (*see* Port Clinton Harbor) .... I, 543; III, 2055
Port Arthur Canal, Tex., connection with Sabine Lake .... I, 344; II, 1314
Port Chester Harbor, N. Y., improvement of .... I, 123, 858
Port Clinton Harbor, Ohio, improvement of .... I, 543; III, 2055
Port Harford, Cal. (*see* San Luis Obispo Harbor) .... I, 578; III, 2179
Port Huron, Mich.:
  Improvement of Black River at .... I, 529; III, 1996
  Removal of wreck in St. Clair River near .... III, 2047
Port Jefferson Harbor, N. Y., improvement of .... I, 127, 865
Portland, Ky.:
  Enlargement of Louisville and Portland Canal .... I, 452; II, 1763
  Operating and care of Louisville and Portland Canal .... I, 455; II, 1765
Portland, Me.:
  Defenses of, including report on telephone booths and damp-proofing .... I, 9; IV, 2371
  Improvement of harbor .... I, 51, 725
Porto Rico, defenses of .... I, 8, 9, 14, 17
Port Reading, N. J., removal of wreck in Arthur Kill .... I, 159, 956
Port Royal (Beaufort) River, S. C.:
  Defenses of Port Royal Sound, including report on damp-proofing.. I, 9; IV, 2409
  Improvement of .... I, 256; II, 1139
  Improvement of waterway between Beaufort and Charleston, S. C .... I, 255; II, 1138
  Improvement of waterway between Beaufort, S. C., and Savannah (*see* Savannah Harbor) .... I, 257; II, 1141
  Removal of logs from waterway between Beaufort and Charleston, S. C .... I, 257; II, 1140

Port Royal Sound, S. C., defenses of, including report on damp-proofing .... I, 9; IV, 2409
Portsmouth, N. H., defenses at, including report on damp-proofing .... I, 9; IV, 2374
Portsmouth, Ohio, ice pier (*see* Ohio River) .... I, 423; II, 1627
Port Tampa, Fla. (*see* Tampa Bay) .... I, 284; II, 1198
Port Washington Harbor, Wis., improvement of .... I, 484; II, 1855
Portwing Harbor, Wis., improvement of .... I, 468; II, 1809
Position finders, range and .... I, 12, 15, 17
Posts, military:
  Fort Leavenworth, Kans .... I, 5, 21, 23, 703
  Fort Totten, N. Y., building for School of Submarine Defense .... I, 13, 16
  Washington Barracks, D. C .... I, 17, 674, 675, 683; IV, 2934
Potomac Park, Washington, D. C .... I, 658; IV, 2517
Potomac River (*see also* Washington, D. C.):
  Aqueduct Bridge, Washington, D. C., repair of .... I, 652; IV, 2483
  Defenses of Washington, D. C., including report on damp-proofing. I, 9; IV, 2405
  Highway bridge at Washington, D.C., to replace Long Bridge. I, 643, 653; IV, 2484
  Improvement at Washington, D. C .... I, 197; II, 1035
  Improvement below Washington, D. C .... I, 200; II, 1038
  Improvement of Eastern Branch (Anacostia River) .... I, 200; II, 1040
  Memorial Bridge, Washington, D. C .... I, 653; IV, 2484
  Wreck near River View, Md .... I, 218; II, 1071
Potter, Sarah (schooner), removal of wreck of .... I, 103, 820
Powow River, Mass., improvement of .... I, 61, 740
Prairie du Chien, Wis., bridge across Wisconsin River .... I, 648
Precipitation (rain), evaporation, and outflow in valley of Northern and Northwestern Lakes .... I, 665; IV, 2855
Preliminary examinations of rivers and harbors. *See* Examinations.
Presque Isle Harbor, Marquette, Mich., harbor of refuge .... I, 474; II, 1823
Presque Isle Peninsula, Erie, Pa., improvements at, use of land for water-supply purposes, status of title, etc .... I, 557; III, 2115, 2117
Printing Office, Government, Washington, D. C.:
  Construction of new building for .... I, 673; IV, 2919
  Telegraph line .... I, 659; IV, 2517
Projectors, searchlight .... I, 14, 15, 16, 17; IV, 2425
Projects. *See* Fortifications *and* Rivers and harbors.
Providence Harbor and River, R. I.:
  Harbor lines in Pawtucket (Seekonk) and Providence rivers .... I, 640, 825
  Improvement of .... I, 95, 801
  Improvement of Pawtucket River .... I, 95, 799
  Removal of Green Jacket shoal .... I, 96, 803
Provincetown Harbor, Mass., improvement of .... I, 87, 783
Public buildings and grounds, District of Columbia .... I, 658; IV 2517
Public parks. *See* Parks.
Puget Sound, Wash.:
  Bridge at Seattle, across Lake Washington Canal right of way .... I, 645
  Defenses of .... I, 9
  Improvement of, and tributaries .... I, 625; III, 2328
  Improvement of waterway to Lake Washington .... I, 629; III, 2332
  Reexamination of waterway to Lake Washington, with plans and estimates of cost .... I, 630; III, 2340
Puntalunos (vessel), removal of wreck of .... I, 271; II, 1171
Purification of water supply of Washington, D. C., with report concerning preliminary treatment of Potomac water .... I, 657; IV, 2505, 2511
Puyallup River, Wash.:
  Bridge at Tacoma .... I, 648
  Improvement of (*see* Puget Sound) .... I, 625; III, 2328
  Improvement of Tacoma Harbor .... I, 627; III, 2331

Q.

Queenstown Harbor, Md., improvement of .... I, 185, 1007
Quinnipiac River, New Haven, Conn., improvement of .... I, 110, 839
Quito (steamer), removal of wreck of .... I, 556; III, 2104

R.

- Raccoon Creek, N. J., improvement of, I, 173, 991
- Racine Harbor, Wis.:
  - Improvement of, I, 486; II, 1861
  - Reef in Lake Michigan near Wind Point, I, 665; IV, 2883
- Railway, boat, Columbia River, Oreg. and Wash, I, 604; III, 2221
- Rainfall, evaporation, and outflow in valley of Northern and Northwestern Lakes, I, 665; IV, 2855
- Rainier, Mount, National Park, Wash., survey for road, I, 37
- Raisin River, Mich. (*see* Monroe Harbor), I, 528; III, 1995
- Ram Island light-house, Boothbay Harbor, Me., removal of wreck, I, 53, 727
- Rancocas River, N. J.:
  - Bridge at Hainesport, I, 647
  - Improvement of, I, 166, 984
  - Removal of wreck, I, 194, 1023
- Range and position finders, I, 12, 15, 17
- Ranges, rifle, I, 17, 686
- Rappahannock River, Va., improvement of, I, 210; II, 1058
- Raritan Bay and River, N. J.:
  - Improvement of bay, I, 150, 937
  - Improvement of Keyport Harbor, I, 151, 939
  - Improvement of river, I, 152, 943
  - Improvement of Shoal Harbor, I, 154, 948
  - Removal of wreck at Metuchen, I, 159, 955
- Reconnaissances and explorations, military, with report on technical features of engineer operations in the former department of North Philippines, and present department of Luzon, I, 667; IV, 2478, 2903
- Red Hook channel, New York Harbor, N. Y., improvement of, I, 142, 915
- Red Lake, Minn.:
  - Improvement of (*see* Red River of the North), I, 401; II, 1543
  - Survey of, I, 403; II, 1548
- Red Lake River, Minn.:
  - Improvement of (*see* Red River of the North), I, 401; II, 1543
  - Survey of, I, 403; II, 1548
- Red River, La., Ark., Tex., and Ind. T.:
  - Bridge between Alexandria and Pineville, La. (Alexandria and Pineville Bridge Company), I, 644
  - Bridge between Alexandria and Pineville, La. (Shreveport and Red River Valley Railway Company), I, 643
  - Bridge near Shreveport, La, I, 643
  - Gauging (*see* Mississippi River Commission), I, 639; S., 7, 8, 62, 97
  - Improvement of, I, 361; II, 1363
  - Rectification of mouth by Mississippi River Commission, I, 639; S., 3, 40
- Red River of the North, Minn. and N. Dak.:
  - Improvement of, I, 401; II, 1543
  - Survey of Otter Tail Lake and River for reservoir dam, I, 404; II, 1548
  - Survey of Red Lake and Red Lake River for reservoir dam, I, 403; II, 1548
- Redwood Creek, Cal., improvement of, I, 581; III, 2182
- Reflectors, searchlight, I, 14, 15, 16, 17; IV, 2425
- Regulations and rules:
  - For navigation of canals, etc, I, 641
  - For opening of drawbridges, I, 642
- Rehoboth Bay, Del., waterway via, I, 180, 1002
- Reservations, public. *See* Parks.
- Reservoirs:
  - Big Stone Lake, Minn., survey of, I, 404; II, 1549
  - Mississippi River, headwaters, construction of, I, 398; II, 1528
  - Mississippi River, headwaters, operating and care, I, 399; II, 1538
  - Mississippi River, headwaters, survey of flowage lines, I, 398; II, 1532
  - Otter Tail Lake and River, Minn., survey of, I, 404; II, 1548
  - Red Lake and Red Lake River, Minn., survey of, I, 403; II, 1548
  - Traverse Lake, Minn., survey of, I, 404; II, 1549
  - Washington Aqueduct, D. C, I, 654, 655; IV, 2485, 2499
- Revere, Mass., bridge across Saugus River to Lynn, I, 650
- Rice Irrigation and Improvement Association of Louisiana, lock and dam in Mermentau River, I, 641
- Richland Creek, Tenn. (*see* Tennessee River above Chattanooga), I, 417; II, 1592

- Richmond Harbor, Va. (*see* James River) .... I, 216; II, 1065
- Rifle ranges .... I, 17, 686
- Ringleader (barge), removal of wreck of .... I, 145, 924
- Ripley, Ohio, ice pier (*see* Ohio River) .... I, 423; II, 1627
- Rivers and harbors (*see also* Technical details):
  - Appropriations for operations during the past year .... I, 35
  - Appropriations for 1904–5, estimates of .... I, 36, 636
  - Board of Engineers for (*see also* Committee, etc.) .... I, 36, 637
  - Board of Engineers, The .... I, 8, 679
  - Bridges .... I, 642, 650, 651
  - Committee on, House of Representatives. *See* Committee, etc.
  - Engineer divisions .... I, 36
  - Examinations and surveys required to be made by act of 1902 .... I, 36
  - Expenditures during the past year .... I, 35
  - Harbor lines, establishment of .... I, 640
  - Rules governing navigation of canals, etc .... I, 641
  - Rules governing the opening of drawbridges .... I, 642
  - Status of works .... I, 35
- River View, Potomac River, Md., removal of wreck .... I, 218; II, 1071
- Roads:
  - Fort Washakie, Wyo., to Buffalo Fork, Snake River .... I, 675; IV, 2937
  - In military divisions and departments .... I, 667; IV, 2478, 2899
  - In Mount Rainier National Park, Wash .... I, 37
  - In Yellowstone National Park, with technical details concerning construction, etc .... I, 666; IV, 2444, 2885
- Roanoke River, N. C., improvement of .... I, 227; II, 1086
- Rochambeau statue, Washington, D. C .... I, 658; IV, 2517
- Rockhall Harbor, Md., improvement of .... I, 184, 1005
- Rockhaven, N. Dak., ice harbor (*see* Missouri River) .... I, 406; II, 1551
- Rockland Harbor, Me.:
  - Harbor lines in Lermonds Cove .... I, 640, 727
  - Improvement of .... I, 47, 721
- Rockport, Mass.:
  - Construction of harbor of refuge in Sandy Bay, with report relative to completion of project .... I, 62, 740, 742
  - Improvement of harbor .... I, 64, 743
- Rock River, Ill.:
  - Construction of canal around .... I, 496; III, 1920
  - Operating and care of canal around .... I, 395; II, 1496
- Romerly Marsh, Ga., improvement of waterway via .... I, 269; II, 1166
- Rondout Harbor, N. Y., improvement of .... I, 137, 884
- Root River, Wis. (*see* Racine Harbor) .... I, 486; II, 1861
- Rouge River, Mich., improvement of .... I, 528; III, 1993
- Rough River, Ky.:
  - Improvement of .... I, 463; II, 1788
  - Operating and care of lock and dam .... I, 464; II, 1789
- Rules and regulations:
  - For navigation of canals, etc .... I, 641
  - For opening of drawbridges .... I, 642

S.

- Sabine Lake, Pass, and River, Tex.:
  - Connection with Port Arthur Canal .... I, 344; II, 1314
  - Improvement of mouth of river and of channel through lake .... I, 344; II, 1314
  - Improvement of river .... I, 345; II, 1315
  - Improvement of Sabine Pass Harbor .... I, 346; II, 1317
- Saco River, Me., improvement of .... I, 54, 732
- Sacramento County, Cal., bridge of .... I, 646
- Sacramento River, Cal.:
  - Bridge of J. E. Terry across .... I, 647
  - Improvement of .... I, 587; III, 2194
  - Improvement of, by California Débris Commission .... I, 638; III, 2368
- Sag Harbor, N. Y., improvement at .... I, 130, 870
- Saginaw River, Mich., improvement of .... I, 524; III, 1986
- St. Augustine Creek, Ga., bridge across .... I, 652
- St. Augustine Harbor, Fla., improvement of .... I, 275; II, 1181

- St. Clair Canal and River, Mich.:
  - Improvement of .... I, 539; III, 2033
  - Improvement of channels in waters connecting the Great Lakes. I, 532; III, 2001
  - Operating and care of canal .... I, 540; III, 2034
  - Removal of wrecks .... I, 542; III, 2046, 2047
  - Surveys, etc. (*see* Northern and Northwestern Lakes) .... I, 660; IV, 2671
- St. Croix Lake and River, Wis. and Minn., improvement of .... I, 400; II, 1540
- St. Francis, Ark., bridge across St. Francis River .... I, 644
- St. Francis River, Ark. and Mo.:
  - Bridge in Lee County, Ark .... I, 644
  - Bridge at St. Francis, Ark .... I, 644
  - Gauging (*see* Mississippi River Commission) .... I, 639; S., 7, 8, 62, 97
  - Improvement of, in Arkansas .... I, 386; II, 1436
  - Improvement of, in Missouri .... I, 388; II, 1438
- St. George Sound, Fla. (*see* Carrabelle bar and harbor) .... I, 290; II, 1207
- St. Johns River, Fla.:
  - Defenses of, including report on damp-proofing .... I, 9; IV, 2413
  - Harbor lines at Jacksonville .... I, 640; II, 1187
  - Improvement between Jacksonville and the ocean, including dredge construction .... I, 271, 976; II, 1173
  - Improvement between Jacksonville and Palatka, including Orange Mills flats .... I, 273; II, 1178
  - Improvement of Volusia bar, and between Volusia bar and Lake Monroe .... I, 274; II, 1179
  - Removal of water hyacinths, including report on experiments made .... I, 279; II, 1184; IV, 2433
- St. Jones River, Del. (*see* Murderkill River) .... I, 177, 996
- St. Joseph Harbor and River, Mich.:
  - Improvement of harbor .... I, 501; III, 1937
  - Improvement of river .... I, 501, 502; III, 1938
- St. Lawrence River, N. Y.:
  - Cape Vincent Harbor, improvement of .... I, 572; III, 2162
  - Defenses of .... I, 8, 9
  - Long Sault Island, improvement at head of .... I, 574; III, 2168
  - Ogdensburg Harbor, improvement of .... I, 573; III, 2165
  - Ogdensburg to foot of Lake Ontario, removal of shoals .... I, 573; III, 2165
- St. Lawrence River Power Company .... I, 574; III, 2168
- St. Louis, Mo.:
  - Harbor lines in Mississippi River .... I, 640; II, 1455
  - Improvement of Mississippi River between mouths of Missouri and Ohio rivers .... I, 390; II, 1445
  - Survey for waterway to Lockport, Ill .... I, 494, 639; III, 1904; S., 7, 68, 167
- St. Louis Bay and River, Minn. and Wis. (*see* Duluth Harbor) .... I, 466; II, 1794
- St. Mary Park Association, bridge of .... I, 650
- St. Marys River and St. Marys Falls Canal, Mich.:
  - Commercial statistics .... I, 535; III, 2010, 2015
  - Improvement of channels in waters connecting the Great Lakes. I, 532; III, 2001
  - Improvement of Hay Lake and Neebish channels .... I, 537; III, 2027
  - Improvement of river at the falls .... I, 534; III, 2006
  - Operating and care of canal .... I, 535; III, 2010
  - Surveys, etc. (*see* Northern and Northwestern Lakes) .... I, 660; IV, 2671
  - Survey for improvement, final report on .... I, 542
  - Water-power canal at Sault Ste. Marie .... I, 641
- St. Paul, Minn.:
  - *See also* Mississippi River.
  - Gauging Mississippi River at .... I, 405; II, 1549
  - Harbor lines in Mississippi River at .... I, 640; II, 1513
- St. Peters River, Minn. *See* Minnesota River.
- St. Thomas (schooner), removal of wreck of .... I, 103, 819
- Sakonnet River, R. I., improvement of .... I, 94, 798
- Salmon Bay, Wash.:
  - Improvement of waterway via .... I, 629; III, 2332
  - Reexamination of waterway via, with plans and estimates of cost. I, 630; III, 2340
- Salmon River, Conn. (*see* Connecticut River) .... I, 107, 836
- Samamish Lake, Wash. *See* Puget Sound-Lake Washington waterway.
- Sampit River (Georgetown Harbor), S. C. (*see* Winyah Bay) .... I, 246; II, 1122
- San Antonio estuary, Cal. (*see* Oakland Harbor) .... I, 582; III, 2186

- Sandbeach, Mich.:
  - Improvement of harbor of refuge ..... i, 526; iii, 1989
  - Water levels ..... i, 665; iv, 2678
- San Diego Harbor, Cal.:
  - Defenses of ..... i, 9
  - Improvement of ..... i, 575; iii, 2171
- Sandusky Harbor, Ohio, improvement of, including dredge construction ..... i, 545, 979; iii, 2057
- Sandwich Islands. *See* Hawaiian Islands.
- Sandy Bay, Cape Ann, Mass.:
  - Construction of harbor of refuge, with report relative to completion of project ..... i, 62, 740, 742
  - Improvement of Rockport Harbor ..... i, 64, 743
- Sandy Lake, Minn.:
  - Construction of reservoir dam ..... i, 398; ii, 1528
  - Operating and care of reservoir dam ..... i, 399; ii, 1538
- San Francisco Bay and Harbor, Cal.:
  - Defenses of, including report on construction methods, damp-proofing, and transportation of ordnance ..... i, 9; iv, 2417
  - Harbor lines north of China Basin and Mission rock ..... i, 640; iii, 2202
  - Improvement of channel between Straits of Karquines and the Golden Gate ..... i, 583; iii, 2189
  - Improvement of harbor ..... i, 582; iii, 2184
  - Improvement of Oakland Harbor ..... i, 582; iii, 2186
- Sanitary District of Chicago, Ill., connection of Chicago River with drainage canal ..... i, 640
- San Jacinto River, Tex.:
  - Bridge across ..... i, 648
  - Improvement of (*see* Galveston ship channel) ..... i, 351; ii, 1334
- San Joaquin County, Cal., bridge of ..... i, 646
- San Joaquin River, Cal.:
  - Bridge across Mormon channel at Stockton ..... i, 648
  - Improvement of ..... i, 584; iii, 2190
  - Improvement of, by California Débris Commission ..... i, 638; iii, 2368
  - Improvement of Stockton and Mormon channels ..... i, 584, 585; iii, 2190, 2193
- San Juan, P. R., defenses of ..... i, 8, 9, 14, 17
- Sankaty Head, Nantucket Island, Mass., removal of wrecks near Bass Rip ..... i, 104, 820
- San Leandro Bay, Cal.:
  - Bridge between Alameda and Bay Farm Island ..... i, 646
  - Improvement of (*see* Oakland Harbor) ..... i, 582; iii, 2186
- San Luis d'Apra, Guam, defenses of ..... i, 8, 9, 14, 17
- San Luis Obispo Harbor, Cal., improvement of ..... i, 578; iii, 2179
- San Pablo Bay, Cal., improvement of ..... i, 583; iii, 2189
- San Pedro Bay and Harbor, Cal.:
  - Construction of deep-water harbor ..... i, 576; iii, 2173
  - Improvement of Wilmington inner harbor ..... i, 577; iii, 2175
- Santee River, S. C., improvement of ..... i, 248; ii, 1127
- Sarasota Bay, Fla., improvement of ..... i, 284; ii, 1197
- Saugatuck Harbor, Mich., improvement of ..... i, 504; iii, 1945
- Saugatuck River, Conn., improvement of ..... i, 118, 849
- Saugerties Harbor, N. Y., improvement of ..... i, 136, 883
- Saugus River, Mass.:
  - Bridge between Revere and Lynn ..... i, 650
  - Improvement of Lynn Harbor ..... i, 73, 759
- Sauk River, Wis. (*see* Port Washington Harbor) ..... i, 484; ii, 1855
- Sault Ste. Marie, Mich. *See* St. Marys River.
- Sausal Creek, Cal. (*see* Oakland Harbor) ..... i, 582; iii, 2186
- Savannah and Tybee Railroad, bridge across St. Augustine Creek, Ga ..... i, 652
- Savannah Harbor and River, Ga.:
  - Defenses of ..... i, 9
  - Improvement of harbor, including dredge construction ..... i, 257, 980; ii, 1141
  - Improvement of river above Augusta ..... i, 261; ii, 1155
  - Improvement of river between Augusta and Savannah ..... i, 260; ii, 1152
  - Improvement of waterway to Beaufort, S. C. (*see* Savannah Harbor) ..... i, 257; ii, 1141
  - Improvement of waterway to Fernandina, Fla ..... i, 269; ii, 1166
  - Removal of wreck in harbor ..... i, 271; ii, 1171

Sawyer, Emily G. (schooner), removal of wreck of ... I, 103, 820
Sayville, N. Y., improvement of Browns Creek ... I, 133, 874
Schools:
  Engineer School of Application ... I, 19, 674, 675, 689; IV, 2934
  School of Submarine Defense, building for ... I, 13, 16
Schuylkill River, Pa.:
  Bridge at Market street, Philadelphia ... I, 648
  Removal of wreck ... I, 194, 1024
Scituate Harbor, Mass., improvement of, including report on project by the Board of Engineers for Rivers and Harbors ... I, 84, 777
Scuppernong River, N. C., improvement of ... I, 229; II, 1091
Seacoast defenses. *See* Fortifications.
Searchlights, including notes on projectors ... I, 14, 15, 16, 17; IV, 2425
Seattle, Wash.:
  Bridge across right of way of Puget Sound-Lake Washington waterway. I, 645
  Improvement of Puget Sound-Lake Washington waterway ... I, 629; III, 2332
  Reexamination of Puget Sound-Lake Washington waterway, with plans and estimates of cost ... I, 630; III, 2340
Seattle and Montana Railroad Company, bridges of ... I, 645, 647
Seattle and Renton Railway Company, bridge of ... I, 645
Sea walls ... I, 13, 16, 17
Sebewaing River, Mich., improvement of ... I, 525; III, 1987
Secretary Creek (Warwick River), Md., improvement of ... I, 188, 1014
Seekonk (Pawtucket) River, R. I.:
  Harbor lines at Providence ... I, 640, 825
  Improvement of ... I, 95, 799
Service of officers of Corps of Engineers abroad and in the field, with troops. I, 24
Shag rocks, San Francisco Harbor, Cal., removal of ... I, 582; III, 2184
Shaws Cove, New London, Conn. *See* New London *and* Thames River.
Sheboygan Harbor, Wis., improvement of ... I, 483; II, 1853
Sheridan statue, Washington, D. C ... I, 658; IV, 2517
Sherman statue, Washington, D. C ... I, 658; IV, 2517
Sherman, Will (barge), removal of wreck of ... I, 158, 955
Shiawassee River, Mich., improvement of ... I, 525; III, 1986
Shilshole Bay, Wash.:
  Improvement of waterway via ... I, 629; III, 2332
  Reexamination of waterway via, with plans and estimates of cost ... I, 630; III, 2340
Ship channel connecting waters of the Great Lakes, improvement of. I, 532; III, 2001
Ship Island Harbor, Miss., improvement of channel to Gulfport ... I, 320; II, 1266
Ship John light-house, Delaware Bay, removal of wrecks ... I, 165, 971, 972
Shipyard Landing, Pasquotank River, N. C., removal of cribs of logs. I, 228; II, 1088
Shoal Harbor, N. J., improvement of ... I, 154, 948
Shoalwater Bay (Willapa Harbor), Wash., improvement of ... I, 620; III, 2323
Shovelful Shoal, Mass., removal of wreck ... I, 103, 819, 820
Shreveport, La.:
  Bridge across Red River near ... I, 643
  Improvement of Red River at ... I, 361; II, 1363
  Waterway to Jefferson, Tex. (*see* Cypress Bayou) ... I, 365; II, 1372
Shreveport and Red River Valley Railway Company:
  Bridge of, across Bayou des Glaises, La ... I, 648
  Bridge of, across Red River, La ... I, 643
Shreveport Bridge and Terminal Company, bridge of ... I, 643
Shrewsbury River, N. J., improvement of ... I, 155, 950
Simmons Ferry, Little River, La., bridge near ... I, 650
Sinepuxent Bay, Md., waterway via ... I, 180, 1002
Sioux City, Iowa. *See* Missouri River.
Sioux River, S. Dak., ice harbor at Sioux City, Iowa ... I, 406; II, 1551
Sites for fortifications ... I, 13, 14, 15, 17
Siuslaw River, Oreg.:
  Examination and survey at mouth and at and near Florence ... I, 599; III, 2229
  Improvement at mouth ... I, 598; III, 2213
Six-mile Island, Allegheny River, Pa., construction of lock and dam. I, 438; II, 1680
Skagit River, Wash. (*see* Puget Sound) ... I, 625; III, 2328
Skykomish River, Wash. (*see* Puget Sound) ... I, 625; III, 2328
Slack-water systems. *See* Canals *and* Waterways.
Smith Creek, Norfolk Harbor, Va., harbor lines ... I, 640; II, 1089

- Smiths Cove, Thames River, Conn., bridge near New London .... I, 652
- Smyrna River, Del., improvement of .... I, 179, 1000
- Snag boats recently authorized:
  - *See also* Dredge boats.
  - Florida, for works in .... I, 280; II, 1186
  - Texas coast .... I, 354; II, 1339
  - Trinity River, Tex .... I, 354; II, 1338
- Snake River, Idaho, Oreg., and Wash.:
  - Improvement of .... I, 602; III, 2218
  - Road from Buffalo Fork to Fort Washakie, Wyo .... I, 675; IV, 2937
  - Survey between Lewiston, Idaho, and mouth of Imnaha River.. I, 603; III, 2246
- Snodgrass Slough, Cal., bridge across Mokelumne River near mouth of .... I, 646
- Snohomish River, Wash.:
  - Improvement of (*see* Puget Sound) .... I, 625; III, 2328
  - Improvement of Everett Harbor .... I, 631; III, 2334
- Snoqualmie River, Wash. (*see* Puget Sound) .... I, 625; III, 2328
- Soda Lakes, La. (*see* Cypress Bayou) .... I, 365; II, 1372
- Sopchoppy, Fla., bridges across Ocklockonee and Sopchoppy rivers near ... I, 652
- Sopchoppy River, Fla., bridge near Sopchoppy .... I, 652
- Sorrel Bayou, La. (*see* Bayou Plaquemine) .... I, 332; II, 1289
- South Atlantic States, removal of water hyacinths from Florida waters, including report on experiments made .... I, 279; II, 1184; IV, 2433
- South Branch, Chicago River, Ill. *See* Chicago Harbor and River.
- South Bristol, Me., bridge across the Gut .... I, 652
- South Carolina, defenses of coast, including report on damp-proofing.. I, 9; IV, 2409
- South Chicago Harbor, Ill. (*see* Calumet Harbor) .... I, 493; III, 1896
- South Edisto River, S. C., waterway via, with estimates of cost .... I, 255; II, 1132
- South End Bridge, across Connecticut River between Springfield and Agawam, Mass .... , 652
- Southern Branch, Elizabeth River, Va.:
  - Improvement of Norfolk Harbor and its approaches, including Hospital Point .... I, 219; II, 1074
  - Improvement of waterway to Albemarle Sound, via Currituck Sound I, 226; II, 1084
  - Improvement of waterway to sounds of North Carolina, via Pasquotank River .... I, 225; II, 1083
- Southern Pacific Company:
  - Bridge of, across Calcasieu River, La .... I, 648
  - Bridge of, across Mormon channel, Stockton, Cal .... I, 648
- Southern Railway Company, bridge of .... I, 646
- South Haven Harbor, Mich., improvement of .... I, 503; III, 1942
- South Hero Island channel, Lake Champlain, Vt., improvement of .... I, 69
- South Kingston, R. I.:
  - Construction of Point Judith harbor of refuge, with report on easterly detached breakwater .... I, 99, 807, 809
  - Improvement of entrance to Point Judith Pond .... I, 100, 814
- South Milwaukee Harbor, Wis., improvement of .... I, 486; II, 1860
- South Norwalk Harbor, Conn. (*see* Norwalk) .... I, 118, 849
- South Pass, Mississippi River:
  - Examinations and surveys .... I, 328; II, 1278
  - Maintenance of channel .... I, 328; II, 1279
- Southport Harbor, Conn., improvement of .... I, 120, 851
- South River, N. J., improvement of .... I, 153, 945
- Southwest Baltimore, Md., improvement of harbor of .... I, 197; II, 1031
- Southwest Pass, Mississippi River, La., improvement of, including dredge construction .... 1, 326, 980; II, 1277
- Southwest Spit, New York Harbor, N. Y., removal of obstructions .... I, 145, 925
- Sparrow Point, Baltimore Harbor, Md., harbor lines in Patapsco River. I, 640; II, 1033
- Springdale, Pa., construction of lock and dam in Allegheny River ... I, 438; II, 1680
- Springfield, Mass., South End Bridge across Connecticut River to Agawam. I, 652
- Spring Garden, Baltimore, Md.:
  - Bridge at .... I, 649
  - Improvement of harbor at .... I, 197; II, 1031
- Spring Lake, Mich., bridge across Grand River to Grand Haven .... I, 649
- Spuyten Duyvil Creek, N. Y. (*see* Harlem River) .... I, 132, 872
- Squan (Manasquan) River, N. J., improvement of .... I, 157, 953

Stage Harbor, Mass. (*see* Chatham Harbor) .... I, 88, 785
Stamford Harbor, Conn., improvement of .... I, 120, 850
Starve Island reef, Lake Erie, removal of wreck .... I, 556, ; III, 2105
Staten Island, N. Y., recommendation for stone monuments to mark established harbor lines .... I, 141
Staten Island Sound (Arthur Kill), N. Y. and N. J.:
  See also Staten Island.
  Improvement of .... I, 147, 932
  Removal of wrecks .... I, 158, 159, 955, 956
Statistics of commerce, Sault Ste. Marie canals, Mich .... I, 535; III, 2010, 2015
Statues, memorials, etc.:
  In public grounds, Washington, D. C .... I, 658; IV, 2517
  Memorial Bridge, Washington, D. C .... I, 653; IV, 2484
  Monuments to Gens. Francis Nash and William Lee Davidson .. I, 676; IV, 2939
Steamboats:
  See also Dredge *and* Snag boats, *and* Wrecks.
  Rules governing running of, on certain streams .... I, 641
Steelmanville, N. J., bridge across Patcong Creek .... I, 651
Steubenville, Ohio, bridge across Ohio River to Cross Creek Township, W. Va. I, 644
Steubenville Bridge Company, bridge of .... I, 644
Stilaguamish River, Wash. (*see* Puget Sound) .... I, 625; III, 2328
Still Bluff, N. C., bridge across Black River .... I, 648
Stillwater Harbor, Minn. (*see* St. Croix River) .... I, 400; II, 1540
Stockbridge Landing, Lake Winnebago, Wis. (*see* Fox River) .... I, 489; II, 1866
Stockton, Cal.:
  See also San Joaquin River.
  Bridge across Mormon channel .... I, 648
Stockton channel, San Joaquin River, Cal., improvement of. I, 584, 585; III, 2190, 2193
Stone Bridge, Sakonnet River, R. I., alteration of .... I, 94, 798
Studhams, Milton R. (schooner), removal of wreck of .... I, 165, 971
Sturgeon Bay and Lake Michigan Canal, Wis.:
  Improvement of, including harbor of refuge .... I, 478; II, 1841
  Operating and care .... I, 480; II, 1846
Subic Bay, Philippine Islands, defenses of .... I, 8, 9, 14, 17
Submarine defense, including building for school of, etc .... I, 13, 15, 16, 17
Sullivan Falls Harbor, Me., improvement of .... I, 40, 714
Sullivan Island shore, Charleston, S. C., improvement at .... I, 253; II, 1134
Sullivan River, Me., improvement of Sullivan Falls Harbor .... I, 40, 714
Sulphur River, Ark. and Tex. (*see* Red River) .... I, 361; II, 1363
Sunken craft. *See* Wrecks.
Superior Bay and Harbor, Wis.:
  Improvement of .... I, 466; II, 1794
  Removal of wreck in Lake Superior .... II, 1828
Superior Lake (*see also* Northern and Northwestern Lakes):
  Commercial statistics, Sault Ste. Marie canals, Mich .... I, 535; III, 2010, 2015
  Final report on survey of waterway to Lake Huron .... I, 542
  Harbor lines at Duluth, Minn .... I, 640; II, 1828
  Improvement and care of waterway to Keweenaw Bay .... I, 471, 472; II, 1815
  Removal of wreck in waterway to Keweenaw Bay .... I, 475; II, 1827
  Removal of wrecks near Duluth .... II, 1828
  Water levels .... I, 665; IV, 2678
  Water-power canal at Sault Ste. Marie, Mich .... I, 641
Supervision of New York Harbor, N. Y .... I, 637; III, 2359
Surface levels. *See* Gauging.
Surveys:
  In military divisions and departments, with report on technical features of engineer operations in the former department of North Philippines, and present department of Luzon .... I, 667; IV, 2478, 2903
  Northern and Northwestern Lakes .... I, 660; IV, 2671
  Of rivers and harbors, estimate of appropriation for .... I, 636
  Of rivers and harbors required to be made by act of 1902 .... I, 36
Susquehanna River, Md., improvement of .... I, 183, 1004
Sutton (steamer), removal of wreck of .... I, 194, 1024
Suwanee River, Fla., improvement of .... I, 288; II, 1202
Swinomish Slough, Wash., improvement of .... I, 632; III, 2336
Synepuxent Bay, Md., waterway via .... I, 180, 1002
Syracuse, Ohio, ice pier (*see* Ohio River) .... I, 423; II, 1627

T.

- Tacoma Harbor, Wash.:
  - Bridge across Puyallup River … I, 648
  - Improvement of … I, 627; III, 2331
- Tallahatchie River, Miss., improvement of … I, 373; II, 1396
- Tampa Bay and Harbor, Fla.:
  - Defenses of, including report on damp-proofing … I, 9; IV, 2413
  - Improvement of bay … I, 284; II, 1198
  - Improvement of Hillsboro Bay and River … I, 285; II, 1200
- Tangier Sound, Md., removal of wrecks in Deal Island Harbor … I, 194, 1024
- Tanks, cable … I, 13, 15, 17
- Target firing … I, 17, 686
- Tar River, N. C., improvement of … I, 231; II, 1094
- Taunton River, Mass.:
  - Improvement of … I, 93, 796
  - Improvement of Fall River Harbor … I, 97, 803
- Tchefuncte River, La., improvement of … I, 337; II, 1301
- Tchula Lake, Miss., improvement of … I, 373; II, 1396
- Teche Bayou, La.:
  - Bridge at Franklin … I, 650
  - Improvement of … I, 334; II, 1295
  - Removal of water hyacinths, including report on experiments made in the Florida district … I, 343; II, 1312; IV, 2433
- Technical details of engineering methods … IV, 2371
  - Baltimore, Md., defenses of, damp-proofing … IV, 2400
  - Boston, Mass., defenses of, damp-proofing … IV, 2374
  - Columbia River, defenses of mouth, construction methods and speaking tubes … IV, 2423
  - Florida, defenses of coast, damp-proofing … IV, 2413
  - Galveston, Tex., defenses of, damp-proofing … IV, 2416
  - Key West, Fla., defenses of, damp-proofing … IV, 2413
  - Long Island Sound, defenses of eastern entrance, damp-proofing … IV, 2387
  - Maine, defenses of coast, telephone booths and damp-proofing … IV, 2371
  - Missouri River, dike and revetment construction … IV, 2437
  - Mobile, Ala., defenses of, damp-proofing … IV, 2414
  - Narragansett Bay, R. I., defenses of, foundations, damp-proofing, and painting of concrete … IV, 2384
  - New Orleans, La., defenses of, damp-proofing … IV, 2415
  - New York, N. Y., defenses of, damp-proofing … IV, 2390
  - North Carolina, defenses of coast, damp-proofing, and use of paint made of coal tar and kerosene oil … IV, 2408
  - Philippine Islands, engineer operations in the former department of North Philippines, and present department of Luzon … IV, 2478
  - Portsmouth, N. H., defenses of, damp-proofing … IV, 2374
  - San Francisco, Cal., defenses of, construction methods, damp-proofing, and transportation of ordnance … IV, 2417
  - Searchlight projectors, notes on … IV, 2425
  - South Carolina, defenses of coast, damp-proofing … IV, 2409
  - Tampa, Fla., defenses of, damp-proofing … IV, 2413
  - Washington, D. C., defenses of, damp-proofing … IV, 2405
  - Water hyacinths, report on experiments for destruction of, in Florida waters … IV, 2433
  - Yellowstone National Park, roads, bridges, etc … IV, 2444
- Telegraph line, Government, Washington, D. C … I, 659; IV, 2517
- Tennessee Central Railroad Company, bridge of … I, 643
- Tennessee River:
  - Chattanooga, Tenn., improvement above … I, 417; II, 1591, 1592
  - Chattanooga, Tenn., to Riverton, Ala., improvement from … I, 418; II, 1591, 1594
  - Gauging (*see* Mississippi River Commission) … I, 639; S., 7, 8, 62, 97
  - Muscle Shoals Canal, Ala., operating and care … I, 419; II, 1605
  - Riverton, Ala., improvement below … I, 419; II, 1591, 1598
- Tensas River, La., improvement of … I, 368, 370; II, 1379
- Terraceia Cut-off, Fla. (*see* Manatee River) … I, 287; II, 1203
- Terry, J. E., bridge of … I, 647
- Texas:
  - Dredge and snag boat for certain works in … I, 354; II, 1339
  - Removal of water hyacinths from waters in … I, 343
- Texas City, Tex., improvement of channel to Galveston … I, 351; II, 1331

Thames River, Conn.:
    Bridge across Smiths Cove near New London .... I, 652
    Improvement of .... I, 106, 834
    Improvement of New London Harbor .... I, 105, 833
Thatcher, Addie (schooner), removal of wreck of .... I, 194, 1024
The Board of Engineers .... I, 8, 679
Three Brothers (sloop), removal of wreck of .... I, 194, 1024
Three-mile Rapids, Columbia River, Oreg. and Wash., improvement at .... I, 604; III, 2221
Thunder Bay River, Mich., improvement of Alpena Harbor .... I, 523; III, 1985
Tickfaw River, La., improvement of, including tributaries .... I, 338; II, 1303
Tillamook Bay and bar, Oreg.:
    Improvement of .... I, 601; III, 2216
    Survey of ocean bar .... I, 602; III, 2239
Tiverton, R. I., improvement of Sakonnet River at .... I, 94, 798
Toledo Harbor, Ohio:
    Harbor lines in Maumee River .... I, 640; III, 2107
    Improvement of, including dredge construction .... I, 542, 979; III, 2049
    Removal of wreck in Maumee Bay .... I, 557; III, 2106
Toledo (steamer), removal of wreck of .... I, 475; II, 1827
Tolomato River, Fla. (*see* St. Augustine Harbor) .... I, 275; II, 1181
Tombigbee River, Ala. and Miss.:
    Columbus to Walkers Bridge, Miss., improvement from .... I, 313; II, 1250
    Demopolis, Ala., improvement below .... I, 310, 311; II, 1246, 1248
    Demopolis, Ala., to Columbus, Miss., improvement from .... I, 312; II, 1249
Tompkinsville, N. Y., removal of wreck off .... I, 145, 924
Tonawanda Harbor, N. Y., improvement of .... I, 563; III, 2144
Tongue Point, Columbia River, Oreg., improvement below .... I, 614; III, 2270
Tonnage, Sault Ste. Marie canals, Mich .... I, 535; III, 2010, 2015
Torpedoes .... I, 13, 15, 17
Totten, Fort, N. Y., building for School of Submarine Defense .... I, 13, 16
Tower, F. D. (canal boat), removal of wreck of .... I, 158, 954
Town Creek, Brunswick County, N. C., improvement of .... I, 242; II, 1113
Town River, Mass., improvement of .... I, 82, 772
Trail Creek, Ind.:
    Improvement of Michigan City inner harbor .... I, 498; III, 1931
    Improvement of Michigan City outer harbor .... I, 498, 499; III, 1931
Traverse Lake, Minn., survey of .... I, 404; II, 1549
Trent River, N. C.:
    Harbor lines at Newbern .... I, 640; II, 1114
    Improvement of .... I, 234; II, 1099
Trinity River, Tex.:
    Bridge across .... I, 648
    Improvement of .... I, 354, 355; II, 1338, 1339
Troops:
    Battalions of Engineers .... I, 5, 7, 18, 669, 686; IV, 2906
    Engineer equipment of .... I, 23, 697
    Service of officers of the Corps of Engineers with .... I, 24
Tucker Beach light-house, N. J., removal of wreck .... I, 194, 1026
Tuckerton Creek, N. J., improvement of .... I, 172, 990
Tug Fork, Big Sandy River, W. Va. and Ky., improvement of .... I, 448; II, 1742
Tunnel, Washington Aqueduct, D. C .... I, 654, 655; IV, 2485, 2499
Turners Cut, N. C., improvement of waterway via .... I, 225; II, 1083
Turtle River, Ga. (*see* Brunswick Harbor) .... I, 267; II, 1164
Twelve-mile Creek, Fla. (*see* Orange River) .... I, 282; II, 1194
Twelve-mile Creek, N. Y. (*see* Wilson Harbor) .... I, 564; III, 2147
Twin Rivers, Wis. (*see* Two Rivers Harbor) .... I, 481; II, 1850
Two Harbors, Minn., improvement of Agate Bay .... I, 465; II, 1793
Two Rivers Harbor, Wis., improvement of .... I, 481; II, 1850
Tyaskin (Wetipquin) Creek, Md., improvement of .... I, 190, 1018

U.

Union Bridge Company, bridge of .... I, 651
Union Lake, Wash.:
    Improvement of waterway via .... I, 629; III, 2332
    Reexamination of waterway via, with plans and estimates of cost. I, 630; III, 2340
Union River, Me., improvement of .... I, 41, 715

United Railways and Electric Company of Baltimore, Md., bridge of ...... i, 649
United States and West Indies Railroad and Steamship Company, bridge of.. i, 643
Urbana Creek, Va., improvement of ...... i, 212; ii, 1060
Uriarte No. 4 (steamer), removal of wreck of...... i, 194, 1024

V.

Vanmatre, A. R., bridge of ...... i, 644
Van Sciver (schooner), removal of wreck of ...... i, 194, 1023
Venango County, Pa.:
    Bridge of, across Allegheny River at Franklin...... i, 651
    Bridge of, across Allegheny River at Kennerdell ...... i, 647
Vermilion Bayou, La., improvement of channel, bay, and passes .... i, 339; ii, 1306
Vermilion Harbor, Ohio, improvement of ...... i, 547; iii, 2064
Vessels:
    See also Dredge *and* Snag boats, *and* Wrecks.
    Rules governing running of steamboats on certain streams ...... i, 641
Vicksburg Harbor, Miss., improvement of...... i, 370; ii, 1385
Vidalia Harbor, La. (*see* Mississippi River Commission)...... i, 639; S., 3, 40
Vinalhaven, Me., improvement of Carvers Harbor...... i, 48, 722
Vineyard Haven, Mass., improvement of harbor at ...... i, 90, 791
Vineyard Sound light-ship, Mass., removal of wreck ...... i, 104, 820
Visayas, department of the, reconnaissances and explorations... i, 667, 669; iv, 2903
Volusia bar, St. Johns River, Fla., improvement of...... i, 274; ii, 1179

W.

Wabash River, Ind. and Ill.:
    Improvement above Vincennes, Ind ...... i, 457, 459; ii, 1772
    Improvement below Vincennes, Ind ...... i, 457; ii, 1772
    Operating and care of Grand Rapids lock and dam...... i, 459; ii, 1773
Waccamaw River, N. C. and S. C.:
    Bridge at Conway, S. C ...... i, 650
    Improvement of ...... i, 243; ii, 1117
Wachapreague Inlet life-saving station, Va., removal of wreck ...... i, 194, 1024
Wadena (barge), removal of wreck of ...... i, 103, 819
Wade Point light, Albemarle Sound, N. C., removal of wreck ...... i, 228; ii, 1088
Wakefield, Va., wharf at Bridge Creek Landing near...... i, 660; iv, 2517
Wallace Creek, S. C., bridge of Colleton County ...... i, 645
Wand, George H. (schooner), removal of wreck of...... i, 542; iii, 2046
Wappinger Creek, N. Y., improvement of...... i, 138, 886
Wappoo Cut, S. C., improvement of ...... i, 255; ii, 1138
War College, Army, Washington, D. C., buildings for ...... i, 674; iv, 2931
War maps ...... i, 673
Warrior River, Ala.:
    Improvement above Tuscaloosa...... i, 309; ii, 1244
    Improvement below Tuscaloosa ...... i, 309; ii, 1245
    Operating and care of locks and dams...... i, 315; ii, 1253, 1256
    Removal of wreck...... i, 324; ii, 1272
Warroad Harbor and River, Minn., improvement of ...... i, 403; ii, 1547
Warwick River, Md., improvement of ...... i, 188, 1014
Washakie, Fort, Wyo., road to Buffalo Fork, Snake River ...... i, 675; iv, 2937
Washington, D. C.:
    Aqueduct Bridge across Potomac River, repair of...... i, 652; iv, 2483
    Aqueduct, Dalecarlia reservoir ...... i, 654; iv, 2485
    Aqueduct, filtration plant, with report concerning preliminary treatment of Potomac water ...... i, 657; iv, 2505, 2511
    Aqueduct, increasing water supply ...... i, 655; iv, 2499
    Aqueduct, maintenance and repair ...... i, 654; iv, 2485
    Aqueduct tunnel and Howard University reservoir .... i, 654, 655; iv, 2485, 2499
    Army War College, buildings for...... i, 674; iv, 2931
    Barracks ...... i, 17, 19, 23, 674, 675, 683; iv, 2934
    Battalions of Engineers ...... i, 7, 18, 686; iv, 2906
    Defenses of, including report on damp-proofing ...... i, 9; iv, 2405
    Engineer depot...... i, 19, 23, 694
    Engineer School of Application, including buildings .... i, 19, 674, 675; iv, 2934
    Executive Mansion and office...... i, 658; iv, 2517
    Government Printing Office, new building for...... i, 673; iv, 2919

- Washington, D. C.—Continued.
  - Highway bridge across Potomac River to replace Long Bridge, I, 643, 653; IV, 2484
  - Improvement of Anacostia River at, I, 200; II, 1040
  - Improvement of Potomac River at, I, 197; II, 1035
  - Improvement of Potomac River below, I, 200; II, 1038
  - Memorial Bridge across Potomac River, I, 653; IV, 2484
  - Public buildings and grounds, and Washington Monument, I, 658; IV, 2517
  - Statues and memorials, I, 658; IV, 2517
  - Survey of United States land within flats of Anacostia River, I, 36
- Washington County (Me.) Railroad Company, bridge of, I, 652
- Washington Lake, Wash.:
  - Bridge at Seattle, across right of way of waterway to Puget Sound, I, 645
  - Improvement of waterway to Puget Sound, I, 629; III, 2332
  - Reexamination of waterway to Puget Sound, with plans and estimates of cost, I, 630; III, 2340
- Washington Monument, D. C., I, 658; IV, 2517
- Washington Parish, La., bridge of, I, 650
- Washita (Ouachita) River, Ark. and La., improvement of, I, 366; II, 1373
- Water craft:
  - *See also* Dredge *and* Snag boats, *and* Wrecks.
  - Rules governing running of steamboats on certain streams, I, 641
- Wateree River, S. C.:
  - Bridge near Kingsville, I, 646
  - Improvement of, I, 249; II, 1128
- Water hyacinths:
  - Removal of, from Florida waters, including report on experiments made, I, 279; II, 1184; IV, 2433
  - Removal of, from Louisiana waters, I, 343; II, 1312
  - Removal of, from Texas waters, I, 343
- Water-level observations:
  - Columbia River, Oreg. and Wash, I, 619; III, 2321
  - Michigan Lake, variations in surface level on east shore, I, 498
  - Mississippi River and principal tributaries, I, 405; II, 1549; S., 7, 8, 62, 97
  - Northern and Northwestern Lakes, including report on outflow, rainfall, and evaporation, I, 665; IV, 2678, 2855
- Waters, navigable. *See* Bridges, Rivers and harbors, *and* Wrecks.
- Water supply, Washington, D. C. *See* Washington, D. C.
- Waterways (*see also* Canals):
  - Beaufort, N. C., to Newbern, I, 235; II, 1101
  - Beaufort, N. C., to New River, I, 236; II, 1103
  - Charleston to Beaufort, S. C., improvement of, I, 255; II, 1138
  - Charleston to Beaufort, S. C., sunken logs, I, 257; II, 1140
  - Charleston to McClellanville, S. C., with estimates of cost, I, 252; II, 1132
  - Chincoteague Bay, Va., to Delaware Bay, Del., I, 180, 1002
  - Galveston to Houston, Tex., I, 351; II, 1334
  - Keweenaw Bay to Lake Superior, Mich., improvement and care, I, 471, 472; II, 1815
  - Keweenaw Bay to Lake Superior, Mich., wreck, I, 475; II, 1827
  - Lockport, Ill., to St. Louis, Mo., via Illinois, Des Plaines, and Mississippi rivers, I, 494, 639; III, 1904; S., 7, 68, 167
  - Norfolk, Va., to Albemarle Sound, N. C., via Currituck Sound, I, 226; II, 1084
  - Norfolk, Va., to sounds of North Carolina, via Pasquotank River, I, 225; II, 1083
  - Portage Lake and Lake Superior canals, improvement and care, I, 471, 472; II, 1815
  - Portage Lake and Lake Superior canals, wreck, I, 475; II, 1827
  - Puget Sound to Lake Washington, bridge at Seattle, Wash, I, 645
  - Puget Sound to Lake Washington, improvement and reexamination of, I, 629; III, 2332, 2340
  - Savannah, Ga., to Beaufort, S. C. (*see* Savannah Harbor), I, 257; II, 1141
  - Savannah, Ga., to Fernandina, Fla, I, 269; II, 1166
  - Shreveport, La., to Jefferson, Tex. (*see* Cypress Bayou), I, 365; II, 1372
  - Superior Lake to Lake Huron, final report on survey, I, 542
- Waukegan Harbor, Ill., improvement of, I, 488; II, 1864
- Western Branch, Elizabeth River, Va., improvement of, I, 220; II, 1076
- Western Bridge Company, bridge of, I, 644
- Western Maryland Tidewater Railroad Company, bridge of, I, 649

Western Pennsylvania Railroad Company, bridges of .... I, 649
West Galveston Bay, Tex., improvement of .... I, 354, 356; II, 1339
West Neebish channel, St. Marys River, Mich., improvement of .... I, 537; III, 2027
Westport Harbor, Conn., improvement of .... I, 118, 849
West River, Conn., bridge between New Haven and Orange, at Kimberly avenue .... I, 651
Wetipquin (Tyaskin) Creek, Md., improvement of .... I, 190, 1018
Weymouth River, Mass., improvement of .... I, 81, 771
Whatcom Creek and Harbor, Wash.:
  Bridge across I and J streets waterway .... I, 645, 646
  Bridge across Whatcom Creek waterway .... I, 647
  Improvement of .... I, 634; III, 2337
White Cliffs, Ark., bridge across Little River .... I, 646
Whitehall, N. Y.:
  Improvement of Narrows of Lake Champlain .... I, 72, 752
  Removal of wrecks in Lake Champlain near .... I, 73, 753
Whitehouse, Ky., bridge across Levisa Fork, Big Sandy River .... I, 647
White House, Washington, D. C .... I, 658; IV, 2517
White Lake Harbor, Mich., improvement of .... I, 512; III, 1962
White River, Ark.:
  Bridge between Arkansas and Desha counties .... I, 643
  Bridge between Baxter and Marion counties .... I, 644
  Bridge at Newport .... I, 642
  Gauging (*see* Mississippi River Commission) .... I, 639; S., 7, 8, 62, 97
  Improvement by open-channel work .... I, 379; II, 1418
  Improvement of Buffalo Fork .... I, 382
  Improvement of upper river by locks and dams .... I, 381; II, 1420
White River, Ind., improvement of .... I, 460; II, 1775
White River Railway Company, bridge of .... I, 644
Wicomico River, Md., improvement of .... I, 189, 1017
Willamette River, Oreg.:
  Improvement above Portland .... I, 609; III, 2257
  Improvement below Portland .... I, 612; III, 2263
Willapa River and Harbor, Wash., improvement of .... I, 620; III, 2323
Willets Point, N. Y., building for School of Submarine Defense at Fort Totten. I, 13, 16
Williams, O. C. (steamer), removal of wreck of .... I, 281; II, 1187
Williamsport (steamer), removal of wreck of .... I, 103, 819
Willow River, Minn. (*see* Mississippi River reservoirs) .... I, 398; II, 1531
Wilmington, Cal.:
  Construction of deep-water harbor in San Pedro Bay .... I, 576; III, 2173
  Improvement of inner harbor .... I, 577; III, 2175
Wilmington, Del.:
  Bridge across Brandywine Creek .... I, 649, 650
  Improvement of harbor .... I, 174, 992
Wilmington, N. C.:
  Defenses of Cape Fear River, including report on damp-proofing and on use of paint made of coal tar and kerosene oil .... I, 9; IV, 2408
  Improvement of Cape Fear River at and below .... I, 240; II, 1109
  Improvement of Cape Fear River above .... I, 239; II, 1105
Wilson Harbor, N. Y., improvement of .... I, 564; III, 2147
Wilson, Pa., harbor lines in Monongahela River .... I, 640; II, 1698
Wilson, Point, Cal. (*see* San Pablo Bay) .... I, 583; III, 2189
Wilson, Thomas (steamer), removal of wreck of .... II, 1828
Wind Point, Lake Michigan, Wis., reef off .... I, 665; IV, 2883
Winnebago Lake, Wis. (*see* Fox River) .... I, 489; II, 1866
Winnibigoshish Lake, Minn.:
  Construction of reservoir dam .... I, 398; II, 1528
  Operating and care of reservoir dam .... I, 399; II, 1538
Winslow, Richard (barge), removal of wreck of, in Straits of Mackinac .... I, 542; III, 2046
Winthrop Cove, New London, Conn. (*see* New London) .... I, 105, 833
Winyah Bay, S. C., improvement of .... I, 246; II, 1122
Wisconsin Central Railway Company:
  Bridge of, across Fox River .... I, 645
  Bridge of, across Mississippi River .... I, 650
Wisconsin Entrance, Duluth Harbor, Minn., improvement of .... I, 466; II, 1794

Wisconsin River, Wis.:
  Bridge at Prairie du Chien ..... I, 648
  Improvement of (*see* Fox River) ..... I, 489; II, 1866
Withlacoochee River, Fla., improvement of ..... I, 288; II, 1202
Wolf River, Memphis, Tenn. (*see* Mississippi River Commission) ..... I, 639; S., 3, 40
Wolf (Ahnapee) River, Wis. (*see* Ahnapee Harbor) ..... I, 480; II, 1847
Wolf River (tributary of the Fox), Wis. (*see* Fox River) ..... I, 489; II, 1866
Woodbridge Creek, N. J., improvement of ..... I, 149, 935
Woods Hole channel, Mass., improvement of ..... I, 91, 793
Wrecks, etc., removal of ..... I, 35
  Albany, N. Y ..... I, 139, 888
  Albemarle Sound, N. C ..... I, 228; II, 1088
  Apalachicola, Fla., opposite ..... I, 306; II, 1236
  Arthur Kill, N. Y. and N. J ..... I, 158, 159, 955, 956
  Ashley River, S. C ..... I, 257; II, 1140
  Bass Rip, Mass ..... I, 104, 820
  Bayonne, N. J ..... I, 159, 955
  Beaufort-Charleston, S. C., waterway, sunken logs ..... I, 257; II, 1140
  Bergen Point, N. J., opposite ..... I, 158, 954
  Bergen Point reef, N. J., on ..... I, 158, 954
  Black Warrior River, Ala ..... I, 324; II, 1272
  Boothbay Harbor, Me ..... I, 53, 727
  Boston Harbor, Mass ..... I, 88, 785
  Braddock Point light station, Lake Ontario, N. Y ..... I, 575; III, 2169
  Bronx River, N. Y ..... I, 138, 139, 887
  Brooklyn, N. Y., East River ..... I, 139, 887
  Buffalo Bayou, Tex ..... I, 360, 361; II, 1347
  Buttermilk channel, New York Harbor, N. Y ..... I, 145, 925
  Camden, N. J., Cooper Creek ..... I, 194, 1024
  Cape Poge light-house, Mass ..... I, 103, 819
  Carters Creek, Va ..... I, 218; II, 1071
  Champlain Lake, N. Y. and Vt ..... I, 73, 753
  Charleston-Beaufort, S. C., waterway, sunken logs ..... I, 257; II, 1140
  Chatham, Mass., off Hardings Beach light ..... I, 103, 820
  Chincoteague light-house, Va ..... I, 194, 1024
  Cleveland Harbor, Ohio ..... I, 556; III, 2105
  Coeymans (North), N. Y ..... I, 139, 888
  Cohansey Creek, N. J ..... I, 194, 1024
  Cooper Creek, N. J ..... I, 194, 1024
  Cross Ledge light-house, Delaware Bay ..... I, 165, 971
  Cumberland River, Dover Island Chute ..... I, 417; II, 1589
  Cumberland Sound, Ga. and Fla ..... I, 271; II, 1171
  Deal Island Harbor, Md ..... I, 194; 1024
  Delaware Bay and River ..... I, 165, 971, 972
  Dover Island Chute, Cumberland River ..... I, 417; II, 1589
  Duluth, Minn., Lake Superior near ..... II, 1828
  East River, N. Y ..... I, 139, 887
  Elizabethport, N. J ..... I, 158, 159, 955
  Elizabeth River, N. J ..... I, 159, 955
  Erie Lake ..... I, 556; III, 2103
  Fairport Harbor, Ohio ..... I, 556; III, 2106
  False Egg Island Point, Delaware Bay ..... I, 165, 971
  Fenwicks Island shoal, Md ..... I, 194, 1024
  Galveston Bay, Tex ..... I, 360, 361; II, 1347
  Gowanus Creek, N.Y ..... I, 145, 924
  Green Run Inlet life-saving station, Md ..... I, 194, 1023
  Hampton Roads, Va ..... I, 228; II, 1088
  Handkerchief shoal, Mass ..... I, 103, 820
  Hardings Beach light, Mass ..... I, 103, 820
  Hen and Chickens light-ship, Mass ..... I, 104, 820
  Hoboken, N. J ..... I, 139, 887
  Hoffman Island, New York Harbor, N. Y ..... I, 145, 925
  Hudson River, N. Y. and N. J ..... I, 139, 887, 888
  Hyannis Harbor, Mass ..... I, 103, 819
  Keweenaw Bay-Lake Superior waterway ..... I, 475; II, 1827
  Key West Harbor, Fla ..... I, 281; II, 1187
  Lambs, S. C ..... I, 257; II, 1140

Wrecks, etc., removal of—Continued.
Larabee Landing, Lake Champlain, Vt........ I, 73, 753
Leipsic River, Del .... I, 194, 1025
Little Creek, Del .... I, 194, 1023
Little Duck Creek (Leipsic River), Del .... I, 194, 1025
Lorain Harbor, Ohio........ I, 556; III, 2104
Mackinac Straits, Mich........ I, 542; III, 2046
Main Ship channel, New York Harbor, N. Y .... I, 145, 924, 925
Marine City, Mich .... III, 2047
Maumee Bay, Ohio .... I, 557; III, 2106
Metuchen, N. J .... I, 159, 955
Middle Island light-house, Lake Erie .... I, 556; III, 2103
Mississippi River, above Missouri River........ I, 393; II, 1463
Mississippi River, below Missouri River........ I, 389; II, 1441
Mobile Harbor and River, Ala........ I, 324; II, 1272
Monomoy Point, Mass .... I, 103, 819, 820
Nantucket Sound, Mass .... I, 103, 819, 820
Nauset Harbor, Mass .... I, 88, 785
Newark, N. J .... I, 159, 955
Newark Bay, N. J .... I, 158, 159, 954, 955
Newport News Point, Hampton Roads, Va........ I, 228; II, 1088
New York Harbor, Arthur Kill, N. Y .... I, 158, 159, 955, 956
New York Harbor, Bronx River, N. Y .... I, 138, 139, 887
New York Harbor, Buttermilk channel, N. Y .... I, 145, 925
New York Harbor, East River, N. Y .... I, 139, 887
New York Harbor, Gowanus Creek, N. Y........ I, 145, 924
New York Harbor, Hoffman Island, N. Y........ I, 145, 925
New York Harbor, Hudson River near Hoboken, N. J........ I, 139, 887
New York Harbor, Main Ship channel, N. Y........ I, 145, 924, 925
New York Harbor, Southwest Spit, N. Y........ I, 145, 925
New York Harbor, off Tompkinsville, N. Y .... I, 145, 924
North Coeymans, N. Y .... I, 139, 888
North (Hudson) River, N. Y........ I, 139, 887
North River, N. C........ I, 228; II, 1088
Ontario Lake........ I, 575; III, 2169
Pasquotank River, N. C........ I, 228; II, 1088
Passaic, N. J., in Passaic River .... I, 158, 954
Passaic Bridge, in Passaic River .... I, 158, 954
Passaic light-house, Newark Bay, N. J........ I, 159, 955
Passaic River, N. J........ I, 158, 159, 954, 955
Philadelphia, Pa., Delaware River .... I, 165, 971
Philadelphia, Pa., Schuylkill River........ I, 194, 1024
Poge, Cape, light-house, Mass .... I, 103, 819
Pollock Rip light-ship, Mass .... I, 103, 819
Popes Island, Va........ I, 194, 1024
Portage Lake canals, Mich .... I, 475; II, 1827
Port Huron, Mich., near........ III, 2047
Port Reading, N. J .... I, 159, 956
Potomac River, Md .... I, 218; II, 1071
Ram Island light-house, Boothbay Harbor, Me........ I, 53, 727
Rancocas River, N. J........ I, 194, 1023
Raritan River, N. J........ I, 159, 955
River View, Potomac River, Md .... I, 218; II, 1071
St. Clair River, Mich .... I, 542; III, 2046, 2047
Sankaty Head, Nantucket Island, Mass .... I, 104, 820
Savannah Harbor, Ga........ I, 271; II, 1171
Schuylkill River, Pa........ I, 194, 1024
Ship John light-house, Delaware Bay .... I, 165, 971, 972
Shipyard Landing, Pasquotank River, N. C........ I, 228; II, 1088
Shovelful shoal, off Monomoy Point, Mass .... I, 103, 819, 820
Southwest Spit, New York Harbor, N. Y .... I, 145, 925
Starve Island reef, Lake Erie........ I, 556; III, 2105
Staten Island Sound (Arthur Kill), N. Y. and N. J........ I, 158, 159, 955, 956
Superior Harbor, Wis., Lake Superior, near........ II, 1828
Superior Lake, near Duluth, Minn........ II, 1828
Superior Lake-Keweenaw Bay waterway........ I, 475; II, 1827
Tangier Sound, Md., Deal Island Harbor........ I, 194, 1024

Wrecks, etc., removal of—Continued.
  Toledo Harbor, Ohio, Maumee Bay .... i, 557; iii, 2106
  Tompkinsville, N. Y .... i, 145, 924
  Tucker Beach light-house, N. J .... i, 194, 1026
  Vineyard Sound light-ship, Mass .... i, 104, 820
  Wachapreague Inlet life-saving station, Va .... i, 194, 1024
  Wade Point light, Albemarle Sound, N. C .... i, 228; ii, 1088
  Warrior River, Ala .... i, 324; ii, 1272
  Whitehall, N. Y .... i, 73, 753
  York River, Va .... i, 218; ii, 1071
Wyandotte, Mich. (*see* Detroit River) .... i, 540; iii, 2036

Y.

Yamhill River, Oreg.:
  Improvement of .... i, 609; iii, 2257
  Operating and care of lock and dam .... i, 612; iii, 2261
Yankton, S. Dak. (*see* Missouri River) .... i, 405; ii, 1551
Yaquina Bay, Oreg., improvement of .... i, 600; iii, 2215
Yazoo River, Miss.:
  Improvement above mouth .... i, 373; ii, 1396
  Improvement of mouth, including Vicksburg Harbor .... i, 370; ii, 1385
Yellow Mill Pond, Bridgeport, Conn. (*see* Bridgeport) .... i, 115, 846
Yellowstone National Park, improvement of, with report giving technical details .... i, 666; iv, 2444, 2885
York River, Va.:
  Improvement of .... i, 204; ii, 1050
  Removal of wreck .... i, 218; ii, 1071
Yuba River, Cal. (*see* Sacramento River *and* California Débris Commission) .... i, 587, 638; iii, 2194, 2368

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